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METHODOLOGY INVESTIGATION

PHASE I REPORT

COMPACT RANGE TEST APPLICATIONS

BY

FRANCIS L. DAVIS

Range Support Division
Test Support Directorate

US ARMY ELECTRONIC PROVING GROUND
FORT HUACHUCA, ARIZONA 85613-7110

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The report documents results of initial testing performed on the outdoor compact range located at the US Army Electronic Proving Ground, Fort Huachuca, Arizona. The compact range is an instrument for testing antenna radiation patterns and gain. It employs a large parabolic reflector to collimate radio frequency energy to provide an area in which the wavefronts are nearly perfectly parallel. This area, in which tests may be performed, is known as the quiet zone. The advantage of this type of range over so-called near-field ranges, which cannot correct the curvature of the wavefronts, is increased accuracy at microwave frequencies, and reduced phase error. The report states that the USAEPG compact range is ready for general use testing antennas in the 6- to 40-GHz range. The report calls for investigations into the range's usefulness for measuring radar cross sections, and providing unusually large and uniform electromagnetic fields for tests of electromagnetic interference (EMI) characteristics.

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FOREWORD

a. Georgia Tech Research Institute (GTRI) has designed and fabricated a very large outdoor Compact Range for the US Army Electronic Proving Ground (USAEPG) to test antennas mounted on large vehicles and aircraft. A photograph of this range appears below.

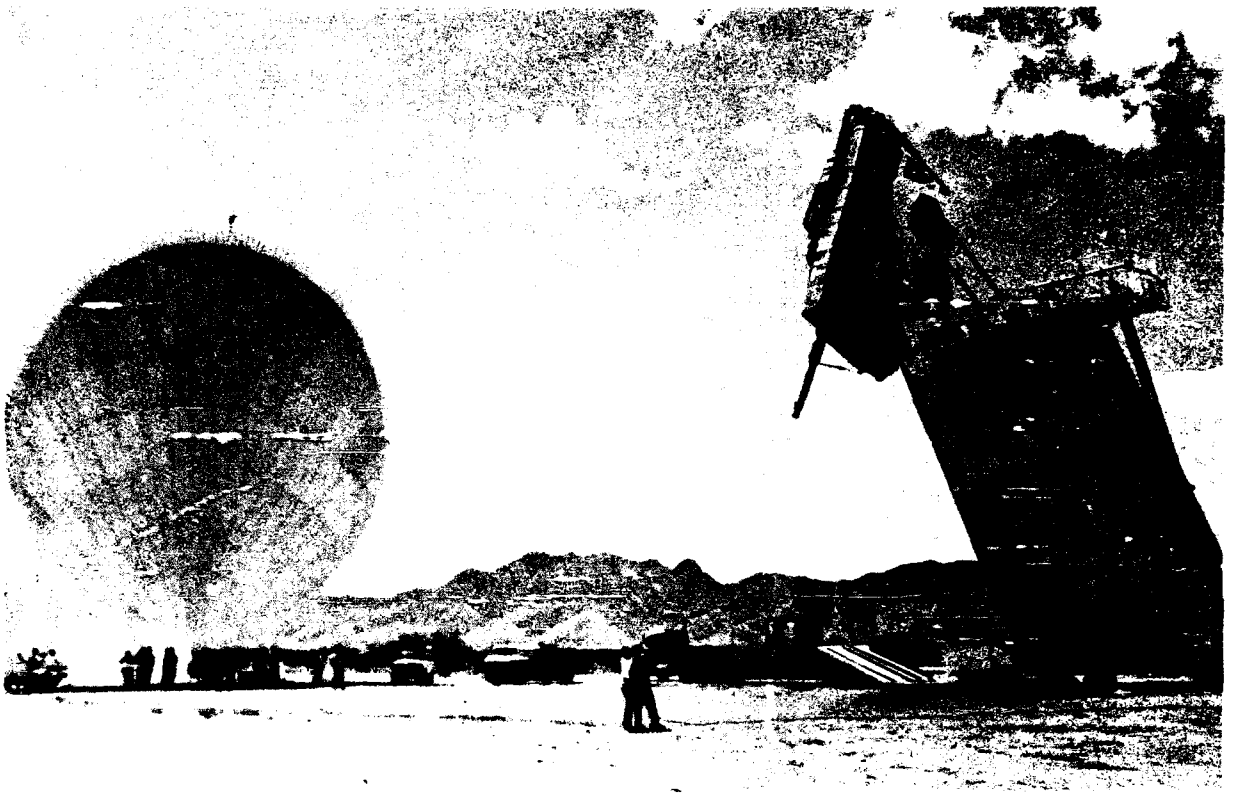

Photo. USAEPG Outdoor Compact Range.

b. The term "compact" refers to the range's ability to perform antenna tests that would require huge tracts of electromagnetically quiet real estate if conventional far-field methods were used. Depending on the combined size of test antenna and host vehicle and the operational frequency, far-field antenna measurement ranges can require very large distances between the antenna under test and the transmission source. For example, for a characteristic dimension of 50 feet, the antenna and receiver must be separated by 5.7 miles at 6 GHz, or 92 miles at 95 GHz. If it is desired to measure very low sidelobe antennas, these distances must be increased even further. The USAEPG Compact Range utilizes a specially designed parabolic reflector to produce a collimated beam of parallel rays with a flat wavefront within a radiation path only 300 feet long.

c. The Compact Range provides improved and new test capabilities to the existing facilities located at the East Range Antenna Complex. Already located at the facility is the Arc Range that provides automated hemispherical antenna measurement capabilities for targets at frequencies

below 8 GHz. The Arc Range has been used for testing up to 18 GHz; however, far-field distance criterion often limits the absolute accuracy of these measurements. The Compact Range enables USAEPG to test large antenna/host vehicle systems from 6 to 40 GHz.

d. In 1985 USAEPG examined a report on the feasibility of designing a large outdoor compact range (ref 1, app G). The report concluded that a compact range producing a 50-foot diameter quiet zone could be used to measure antenna patterns on vehicles. To further define necessary parameters for the compact range, two studies were funded in 1986 to design the required feed horns and to analyze the effects of the surface tolerances associated with building a large reflector (refs 2 and 3, app G). In 1986, USAEPG began to fund the construction of the range, which was completed in 1989.

e. The Compact Range complements the capabilities of the Arc Range by expanding USAEPG's ability to handle large, heavy vehicles and high frequencies. The Compact Range can handle targets up to 70 tons and 50 feet in size at frequencies to 40 GHz. The Compact Range was designed to be a stand-alone system, allowing it to operate independently of the Arc Range. Both ranges share a common computer system and file structure.

SECTION 1. SUMMARY

1.1 BACKGROUND

USAEPG has obtained a compact range facility which can provide a far-field radio frequency (RF) condition in a relatively short distance. The compact antenna range will provide a unique capability to irradiate large target systems with a highly controlled and precisely oriented electromagnetic (EM) field. A significant potential application of this capability is the measurement of "upset events" produced by EM environments that couple directly into the components and circuits of electronic systems.

1.2 PROBLEM

There are other measurements beside antenna patterns for which a compact range is suitable. The cost of making these measurements could be reduced by integrated or combined testing. This process could replace the current procedure of measuring different characteristics of a test item at different facilities.

1.3 OBJECTIVE

The objective of this investigation was to determine how the new Compact Range at USAEPG can be adapted to other measurements such as target return signals and equipment responses to specialized signal environments.

1.4 PROCEDURES

a. Phase I

(1) Determine the capabilities of the Compact Range to perform basic antenna pattern measurements.

(2) Research current methodology and implementation of radar cross section measurements on compact antenna ranges.

(3) Provide an approach to technology development.

(4) Provide an approach to equipment interface.

b. Phase II (follow-on and completion of Phase I)

(1) Determine technology/equipment needed for target return signal measurement and other specialized signal environment measurements (i.e. electronic equipment, antenna/feed horn, and pylon/pedestal).

(2) Provide report with suggested equipment list and methodology.

1.5 RESULTS

a. Antenna Pattern Measurement/Basic Range Functions. The original acceptance testing demonstrated the operation of the hydraulic positioner, RF instrumentation, feeds and reflector, and data collection system. Comparison of the known characteristics of standard gain horn antennas against measurements made with the Compact Range demonstrated the overall performance of the system. The remaining information in this section was obtained during the Phase I study.

(1) Hydraulic Positioner. The control system software was modified to prevent a massive load from accelerating or decelerating too quickly and overstressing the load mounts or the positioner. A low-pass filter was added to the manual positioning control circuit to prevent the same kind of damage due to overstress. The gain of the azimuthal servo loop was reduced to eliminate oscillations observed when the OV-1 Mohawk aircraft was mounted on the positioner. The Mohawk test load closely approached the design limit for maximum azimuthal inertial moment.

(2) RF Instrumentation, Feeds, and Reflector

(a) Dynamic Range and Signal-to-Noise Ratio. The RF instrumentation system demonstrated a minimum dynamic range of 50 dB at 40 GHz [with a 10-dB signal-to-noise (S/N) ratio]. Feed horns were developed to allow testing from 6 to 40 GHz. The center section of the reflector was designed and constructed to mechanical tolerances sufficient for future applications up to 95 GHz; however, current testing was limited to a maximum of 40 GHz.

(b) Quiet Zone Field. The preliminary evaluation study performed by Quick Reaction Corporation (QRC) extracted a high spatial frequency ripple on the GTRI field probe data of approximately ± 2.5 degrees in phase and ± 0.4 decibels (dB) in amplitude. (Please see figure 1, top of page 1-3, for clarification of terms dealing with ripple.) This report also evaluated the presence of low spatial frequency ripple in the quiet zone. Peak-to-peak amplitude ripple, as measured by the GTRI field probe, was < 2.6 dB at frequencies below 12.4 GHz; < 4.9 dB from 12.4 to 18 GHz; < 3.5 dB from 18 to 26.5 GHz; and < 4.2 dB from 26.5 to 40 GHz. Due to physical limitations of the field probe used by GTRI, only the central 13-foot diameter section of the quiet zone was measured. This field probe was not well suited to perform these measurements with a high degree of repeatability in positioning accuracy.

(c) Multipath and Clutter Signals. Using the time-domain mode of the range receiver, the coupling between the feed antenna and the antenna under test was measured, and investigations of any multipath signals that may be present were performed. Measurements of RF coupling from the feed horn to the antenna under test were taken using the spare feed horn antenna as the test item. With the test antenna suspended approximately 22 feet in front of the positioner's center of rotation, and with the positioner at 0 degrees elevation, a worst-case coupling of 28 dB below the desired signal response was measured. Clutter from around the reflector and positioner structures was about 25 to 13 dB below the desired response.

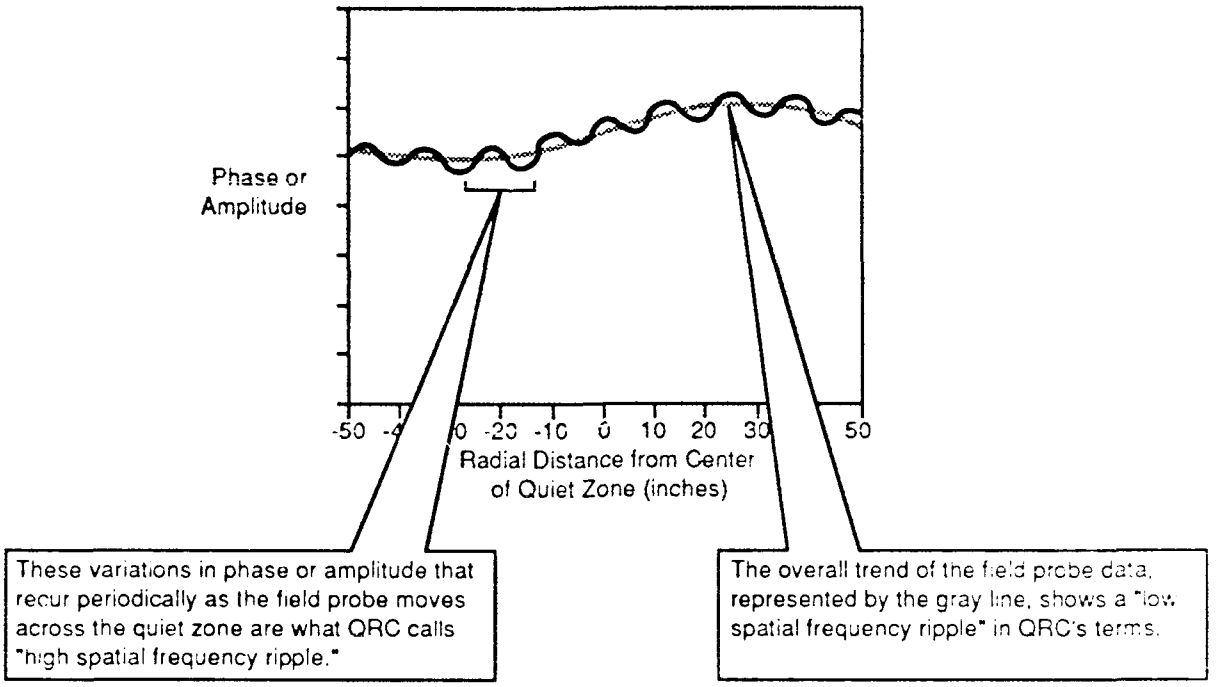

Figure 1. Definitions of terms associated with quiet-zone ripple.

(3) Data Collection System. Data presentations on the range operator's display and hardcopy plots of the antenna pattern data were as expected and in accordance with design goals.

(4) Pattern Measurement Performance. Relative pattern measurements of standard gain horn antennas were made at low, middle, and high frequencies within each of six RF bands from 6 to 40 GHz. These measurements show a qualitative match between the known patterns of the antennas and the results produced by the Compact Range. It was, however, determined that the 6-to-18-GHz local oscillators required attenuators to prevent saturation of the amplifier.

b. Radar Cross Section Measurement. GTRI has presented a white paper on the possibility of using the Compact Range to perform gated radar cross section (RCS) measurements (app F). Their report suggests modifying the existing RF feed enclosure to accommodate the mounting of receive and transmit feeds adjacent to one another at the focal point of the reflector. Modifications to the range's hardware and software would also be required. The GTRI report provides only a general technical approach to RCS measurement using the Compact Range; it does not specify the hardware that would be required. Several companies (March Microwave, Hughes, Flam and Russell, Scientific Atlanta, and Harris Corporation) have developed RCS measurement ranges based on the Hewlett Packard (HP) 8510 network analyzer as the range receiver (the same receiver used at USAEPG). Due to limited resources, we have not yet investigated the approaches used by these other ranges, nor have we confirmed the findings of the GTRI report.

c. Specialized Electromagnetic Environment Tests. Due to limited resources, we were unable to investigate the range's use for EMI testing.

d. Instrumentation and Interfacing. We purchased spares to back up the range's RF mixers and the fiber-optic instrumentation bus extenders. All of these items are critical to the operation of the range. We also obtained precision attenuators and test cables capable of operation to 50 GHz, as well as precision torque wrenches. The wrenches help prevent workers from overtightening and damaging the millimeter-wave RF connections.

1.6 ANALYSIS

a. Antenna Pattern Measurement/Basic Range Functions

(1) Hydraulic Positioner. The M1 Abrams tank and OV-1 Mohawk aircraft represent conditions near the maximum design values for total weight and azimuthal inertial moment. Hardware and software modifications to the positioning system have successfully fined-tuned the system to handle these test loads.

(2) RF Instrumentation, Feeds, and Reflector

(a) Dynamic Range and Signal-to-Noise Ratio. The Compact Range was designed for a minimum dynamic range of approximately 68 dB at 40 GHz (with a 10-dB S/N). This design goal assumed a test antenna with a nominal gain of 10 dB referenced to isotropic (dBi). Using the spare feed antennas (which have gains close to 10 dBi) as test antennas, the measured dynamic range--50 dB--falls short of the design goal.

(b) Quiet Zone Field. A perfect field would exhibit no variations in amplitude or phase across the quiet zone. This would be an indication that the RF field was completely uniform and planar in nature. The closer the actual measurements are to this ideal, the closer the quiet zone approaches the theoretical far-field condition. The design goal of 3 dB peak-to-peak amplitude ripple appears to be well within the reach of the present range geometry and instrumentation, taking into account the mechanical limitations of the field probe that was used.

(c) Multipath and Clutter Signals. Multipath and clutter effects degrade the range's potential accuracy. Direct coupling from the feed to the antenna under test is a potentially significant source of interference. Direct coupling effects will be most pronounced for higher elevation angles where the antenna under test is pointed more directly at the feed. Testing showed that direct coupling was 28 dB down from desired response when the antenna under test (gain: 10 dBi) was at an elevation of 0 degrees. This coupling will increase with higher-gain antennas and greater elevation angles. Clutter is also a potential source of degraded accuracy. Testing showed clutter levels 13 dB below the desired response. Undesired responses 13 dB below the desired level of response will result in a response error of ± 0.2 dB.

(3) Data Collection System. The data collection system successfully supported basic measurements of antenna patterns.

(4) Pattern Measurement Performance. Qualitative comparisons of the data were in agreement with the manufacturer's published data for typical standard gain horn antennas. Mainlobe beamwidths and sidelobe structures were very symmetrical at all test frequencies.

b. Radar Cross Section Measurement. GTRI's white paper indicates that it is technically feasible to perform gated RCS measurements on the USAEPG Compact Range. A major concern is the large radar cross section presented by the positioner pedestal and whether this return could be removed by the time-domain gating features of the HP 8510 network analyzer currently used as the range receiver.

c. Specialized Electromagnetic Environment Tests. No testing or study could be performed; therefore, no analysis is possible.

d. Instrumentation and Interfacing. No testing or study could be performed; therefore, no analysis is possible.

1.7 CONCLUSIONS

a. Antenna Pattern Measurement/Basic Range Functions. Successful demonstrations of the data collection, RF instrumentation, and hydraulic positioner systems during acceptance testing showed that the Compact Range has met the original design goals for providing basic antenna pattern measurement capability from 6 to 40 GHz.

(1) Hydraulic Positioner. The hydraulic positioning system is capable of controlling the movement of the kinds of large and heavy loads for which it was designed. Software modifications and the addition of a low-pass filter on the manual control system have been successful in preventing too-rapid acceleration/deceleration of the test vehicle. Adjustment of the azimuth servo loop has greatly reduced or eliminated the oscillations caused by a test load with a high moment of inertia in the azimuth plane.

(2) RF Instrumentation, Feeds, and Reflector

(a) Dynamic Range and Signal-to-Noise Ratio. The results indicate that the RF instrumentation does not meet the design goals for dynamic range at 40 GHz. The measured result of 50 dB is adequate for all but the most critical of antenna pattern measurement requirements (i.e., very low sidelobe antennas of moderate gain). The design goals were based upon empirical estimates of range performance and represent a best-case prediction of performance.

(b) Quiet Zone Field. Preliminary analyses of GTRI field probe data confirmed the physical limitations of the probe and emphasized the need for more detailed characterizations of the field using a laser-corrected field probe capable of spanning the entire 50-foot quiet zone. Because some of the probe data was suspect due to its non-repeatability, any quantitative judgements regarding the quiet zone field should be made with caution. This preliminary probing provided enough data to conclude that the design goal of 3 dB peak-to-peak ripple is attainable with the present range geometry and instrumentation.

(c) Multipath and Clutter Signals. Multipath and clutter signals limit the accuracy of the Compact Range for antenna pattern measurement, and will reduce its sensitivity in applications such as

determination of a target's radar cross section. QRC's preliminary evaluation of the GTRI field probe data concluded that the high spatial frequency ripple of ± 0.4 dB in amplitude and ± 2.5 degrees in phase was most likely due to reflector edge effects. The fact that these values are as low as they are indicates that the reflector's shaped edge serrations are performing as designed to minimize edge diffraction effects in the quiet zone. QRC also concluded that the observed low-frequency ripple was due to a combination of multipath, continuous wave (CW) leakage, and direct coupling from the feed to the antenna under test. The effects of these interference sources could be reduced or eliminated by employing range gating. Range gating involves sending the RF illuminating signal as a brief pulse and gating the receiver circuitry to allow reception over a relatively narrow span of time corresponding to the time-of-arrival window of the desired signal response.

(3) Data Collection System. The data collection system is adequate for the purpose of collecting, reducing, and presenting antenna pattern measurements. The system will support the basic antenna pattern measurement mission of the Compact Range.

(4) Pattern Measurement Performance. The preliminary qualitative measurements of standard gain horn antenna patterns indicate that the existing range configuration is capable of performing relative antenna pattern measurements with some degree of confidence.

b. Radar Cross Section Measurement. We feel that it is technically feasible to develop the capability to perform RCS measurements on the USAEPG Compact Range.

c. Specialized Electromagnetic Environment Tests. No testing or study could be performed; therefore, no conclusions are possible.

d. Instrumentation and Interfacing. No testing or study could be performed; therefore, no conclusions are possible.

1.8 RECOMMENDATIONS

a. Antenna Pattern Measurement/Basic Range Functions

(1) Hydraulic Positioner. No further modifications to the hydraulic positioner should be made, based on the successful control of test vehicles near the maximum design values for weight and azimuthal moment of inertia.

(2) RF Instrumentation, Feeds, and Reflector

(a) Dynamic Range and Signal-to-Noise Ratio. The present dynamic range of 50 dB at 40 GHz (with a 10-dB S/N) is adequate for the antenna pattern measurement mission of the USAEPG Compact Range. Dynamic range may improve if in the future more accurate measurements of the quiet zone field lead to improved alignment of the feed location or reflector panels in the central zone of the reflector.

(b) Quiet Zone Field. The field probe used to evaluate the quality of the quiet zone field provided a preliminary look at the central 13-foot diameter section of the 50-foot diameter quiet zone. In order to further align the reflector and characterize the quiet zone, a precision laser-corrected field probe should be used for further

testing. Detailed analyses of extraneous reflected and diffracted RF energy that would corrupt the quiet zone field cannot be performed without a more complete and accurate database.

(c) Multipath and Clutter Signals. Investigation into the application of hardware and software gating in order to reduce and/or eliminate clutter sources is required. These methods would greatly facilitate the accurate measurement of target returns and also yield greater accuracy for antenna pattern and gain measurements. The optimized combination of hardware and software gating can greatly reduce or eliminate coupling between the feed antenna and the antenna under test, ground clutter, and clutter associated with the reflector backstructure and range architecture.

(3) Data Collection System. Additional hardware and software should be developed to accommodate future applications of the Compact Range, such as the measurement of target return signals, upset effects, and the generation of specialized signal environments.

(4) Pattern Measurement Performance. More precise antenna pattern confirmation testing using standard gain horns of known accuracy should be performed to quantify the ability of the Compact Range to accurately measure absolute antenna gains. More extensive and accurate field probing of the quiet zone field is required to gain confidence in the uniformity of the illuminating RF field and to provide a basis for engineering conclusions on the absolute accuracy of the measurements.

b. Radar Cross Section Measurement. GTRI's study does not address additional software or hardware requirements in sufficient detail to make specific recommendations at this time. The Compact Range is currently configured to perform basic antenna pattern measurements with the range receiver operating in a CW dual-source mode with a single antenna at the reflector's focal point. In order to fully characterize the ability of the Compact Range to perform RCS measurements, we should investigate the tradeoffs involved in implementing specific hardware and software modifications. These studies should include, but not be limited to: single- versus dual-feed systems; optimization of the transmitted pulse width, receiver gate width, and delay time; and selection of pulse repetition rates that will avoid interference in the receiver's intermediate frequency (IF) passband.

c. Specialized Electromagnetic Environment Tests. We recommend investigation of a forthcoming piece of test instrumentation that would permit simulation of a variety of special types of signals--the Hewlett Packard HP 8791 Model 21 Frequency Agile Signal Simulator (HP FASS). This equipment, scheduled to be released in late 1991, will perform 100-nanosecond phase-coherent frequency-agile switching from 10 MHz to 18 GHz. Typical instantaneous bandwidths of up to 40 MHz are possible. The system will be able to simulate multi-emitter threats. User-defined waveform generation will allow for real-time control of complex signals and threat scenarios. Some of the signals that could be simulated with this system are: 800-MHz-wide barrage noise, frequency-agile chirp signals, spread-spectrum waveforms, variations of radar pulse repetition intervals, sector scanning, and multiphase coded radars.

d. Instrumentation and Interfacing

(1) The acquisition of network analyzer test and calibration sets would allow checkout and troubleshooting of various equipment such as coaxial cables, filters, isolators, amplifiers, and mixers.

(2) The present HP 8501B range receiver should be upgraded to an 8501C model. The present firmware has several known deficiencies that would be corrected by the upgrade. For example, the 8501B model exhibits problems in implementing the 'fast CW' mode for some data point sets. The range software currently handles this limitation; however, upgrade to the 8501C receiver would eliminate the problem and the need for a software workaround. Eliminating this limitation would improve the efficiency of the range by increasing data throughput.

(3) Another factor related to the efficiency of the range's data throughput is the speed with which the RF source can switch frequencies. A tenfold improvement in switching speed would be realized by replacing the present HP 8340B RF source with the HP 83640A (used in conjunction with the upgraded range receiver). These hardware upgrades would have a minimal impact on compatibility with the range operating software. The resultant increase in data throughput should decrease the occurrence of hydraulic positioner overspeeds. It may also be necessary to replace the local oscillator source in order to fully realize the improvement in switching speed.

(4) We should acquire spare local oscillator amplifiers to minimize the downtime that occurs when the 6- to 18-GHz unit fails. This unit has failed twice, exhibiting low gain. Results of this study determined that attenuators should be placed on the two local oscillator amplifier inputs in order to prevent the amplifiers from being driven into saturation. The manufacturer (AVANTEK) has not experienced any other reliability problems with these units. The exact failure mechanism is unknown at this time, but we will add attenuators to the inputs in an effort to solve this problem.

(5) We should acquire attenuators to balance the local oscillator signal levels at the test and reference mixers. Thumbwheel-type attenuators should be added to this system to avoid frequent make/break cycles of the RF connectors at the mixer local oscillator injection ports.

SECTION 2. DETAILS OF INVESTIGATION

2.1 OVERALL RANGE DESIGN

a. The Compact Range has several different systems and components that must function together as a unit. The range consists of:

(1) Computer System.

(2) RF Instrumentation System.

(3) Positioner and Hydraulic System.

(4) RF Feeds.

(5) Reflector.

Figure 2 shows the equipment groups and their locations. A functional block diagram appears in figure 3.

b. The primary task of the range is to automatically acquire antenna patterns for antennas mounted on military vehicles. To do this, the computer system commands the instrumentation to specific frequencies and the positioner to specific locations. The end result is either a single pattern or a series of patterns that describe the radiation characteristics of the antenna under test.

c. An ideal compact range would have uniform amplitude and phase over the test zone. In practice, reflection and scattering from various surfaces degrade field uniformity. Indoor compact ranges are usually placed in absorber-lined rooms to suppress undesired reflections.

d. Because of its size, the USAEPG Compact Range had to be built outdoors, making extensive use of absorber impractical. Obviously, there are no wall or ceiling reflections, but ground reflections are more difficult to suppress. Indoor ranges use precise temperature control to maintain range geometry. An outdoor reflector is subject to thermal and wind loads that constantly change its shape, resulting in amplitude and phase variations in the quiet zone. We concluded that a random ripple of 3 dB (± 1.5 dB) could be achieved. This is compatible with the antenna measurement mission of the USAEPG Compact Range.

e. Table I summarizes the design goals for the USAEPG Compact Range.

f. The acceptance testing demonstrated the successful integration and operation of the Compact Range's systems and physical components. As part of this study, standard gain horn measurements, investigations of multipath and clutter signals, and preliminary analyses of the quiet-zone field-probe data were performed. These indicate that the initial design goals have been satisfied.

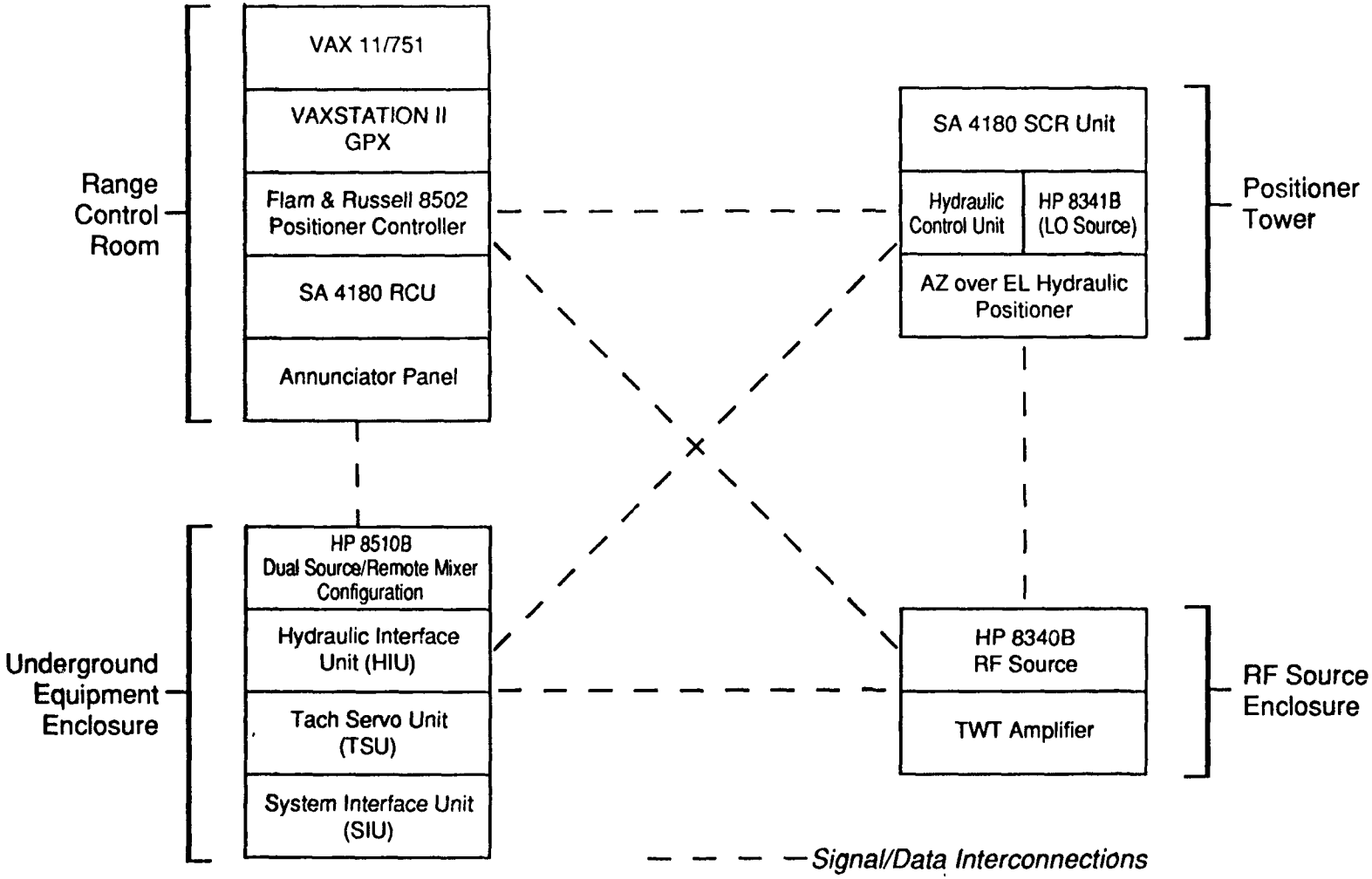

Figure 2. Equipment groups and their locations.

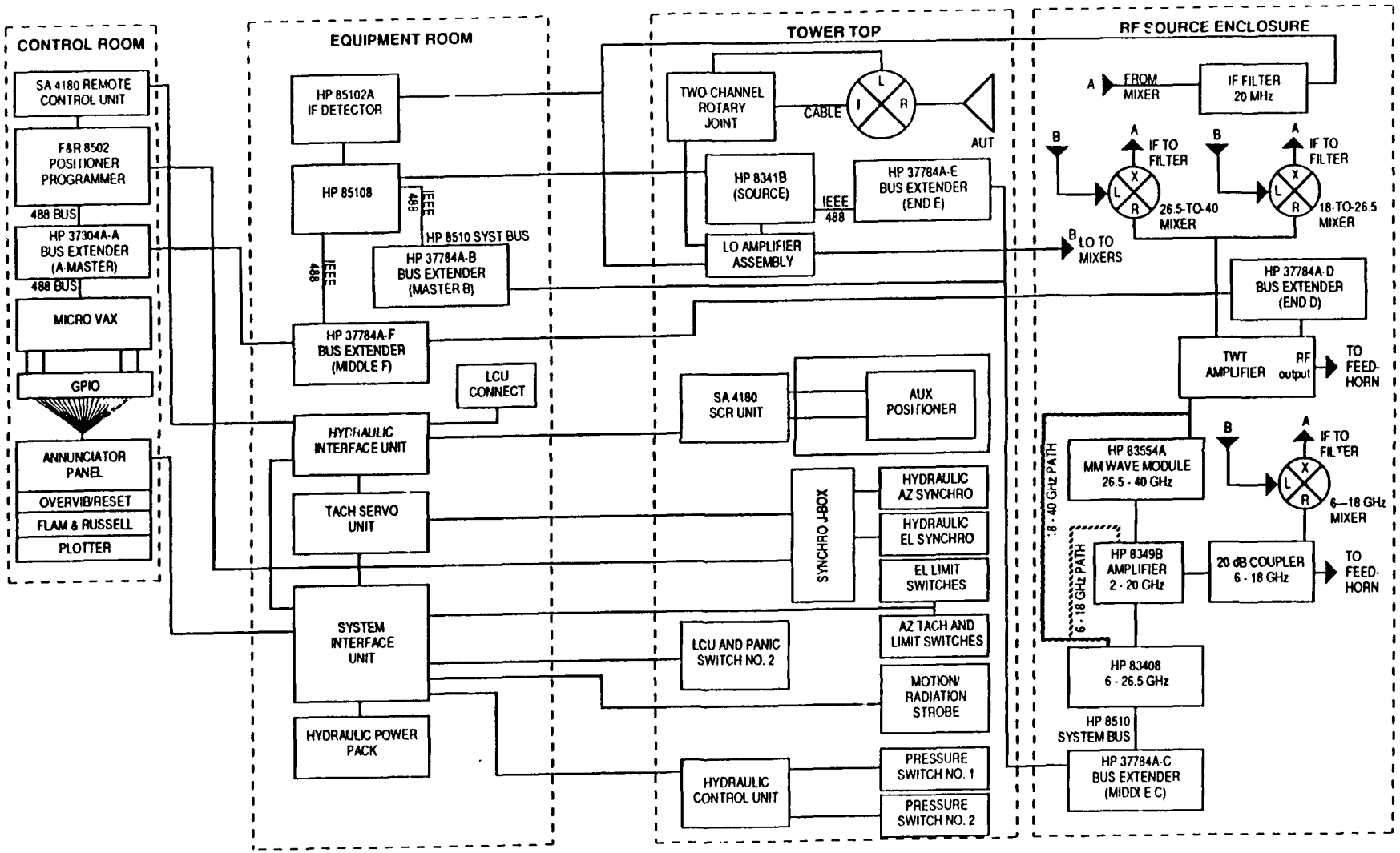

Figure 3. Functional block diagram of the Compact Range.

TABLE I. COMPACT RANGE DESIGN GOALS

Reflector	
Type	Offset-fed paraboloid
Diameter	75 feet
Focal length	150 feet
Panel accuracy	< 0.002 in.
Panel alignment	< 0.005 in. for R < 28 feet < 0.025 in. for 28 < R < 32 feet < 0.050 in. for R > 32 feet
Feeds	
Type	Corrugated horns
Polarization	Linear
Frequency range	6 to 40 GHz in 5 bands: 6 to 8 GHz 8 to 12.4 GHz 12.4 to 18 GHz 18 to 26.5 GHz 26.5 to 40 GHz
VSWR	1.2:1 maximum
Gain	10 dBi
Target Positioner	
Type	Azimuth-over-elevation
Drive	Azimuth- hydraulic motor Elevation- hydraulic cylinders
Maximum target weight	70 tons
Scan limits	Azimuth- continuous rotation or ± 200 degrees Elevation- -1 to 90 degrees
Position transducers	Two-speed synchro (1:1 and 36:1)
Speed regulation	1 percent
Position resolution	0.01 degrees
Instrumentation	
Signal source	Synthesized
Type	Continuous wave
Frequency stability	1 Hz at 1 GHz
Frequency range	10 MHz to 40 GHz (with frequency doubler for 26.5 to 40 GHz)
Power amplifier	Logimetrics TWTA, 18 to 40 GHz, 10 watts maximum
Receiver	Network analyzer (HP 8510B)
Frequency coverage	45 MHz to 110 GHz Harmonic conversion
Measurement	Single-channel phase and amplitude
Measurement Capabilities	
Quiet zone diameter	50 feet
Data collection method	Raster scans
Record increments	0.1 degrees minimum 10.0 degrees maximum
No. of data points per scan	3600 maximum
Multiplexed frequencies	10 maximum
Data analysis	Beamwidths, sidelobe levels, multiple beams, and null depths
Plotting capabilities	
Two-dimensional	Rectangular/polar
Three-dimensional	

2.2 MICROWAVE DESIGN

a. The microwave design of the compact range was undertaken with the goal of providing a basic compact range system initially capable of performing vehicle antenna pattern measurements at frequencies of 6 to 40 GHz with provision for extending the operating frequency to 95 GHz without major modification to the microwave structures. The general configuration of the compact range appears in figure 4 below.

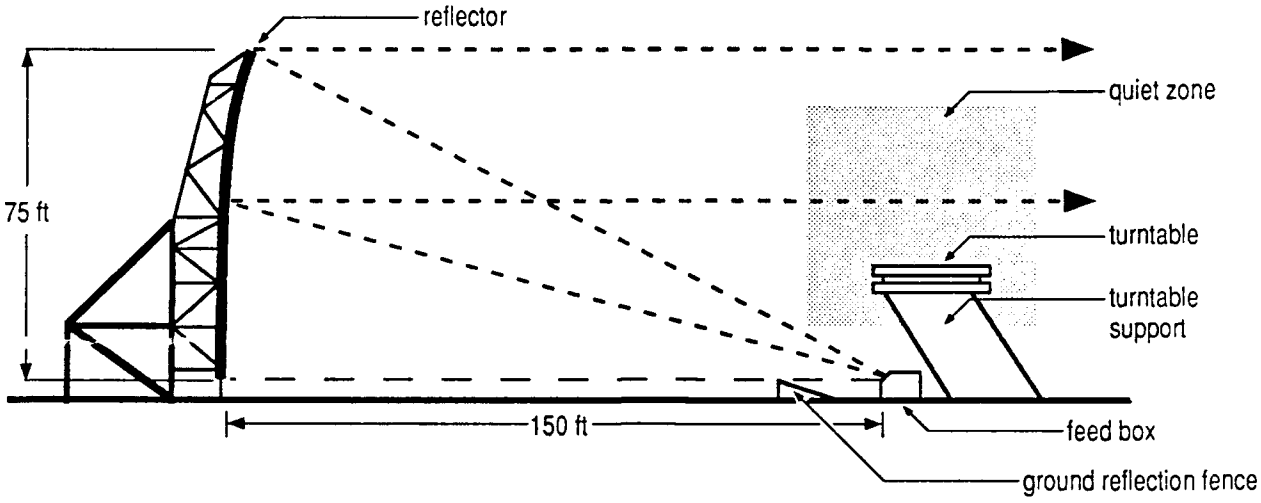

Figure 4. Physical layout of the Compact Range.

b. The preliminary design for the electromagnetic aspects of the range was reviewed and detailed analyses were conducted in key areas (quiet zone size, quality and location, reflector surface tolerance, and interference suppression) to complete the final configuration (ref 1, app G). The final selection of the basic reflector parameters (size, focal length, edge geometry, surface accuracy, etc.) was based on the effect of these parameters on the quality of the quiet zone.

c. The surface quality of a reflector is specified by the magnitude and spatial frequency of its roughness. Conventional compact range design calls for a root-mean-square (RMS) surface roughness of less than 1/100th of a wavelength for all spatial frequencies with a period of greater than three wavelengths. The preliminary reflector design called for serrated edges with a minimum length of 2 feet (12 wavelengths at the lowest frequency of 6 GHz). The serrated edge has an advantage over the rolled edge or absorber edge primarily due to its lower manufacturing cost. The final design determined the number and geometry of the edge serrations for optimum quiet zone quality.

d. The shape and quality of the quiet zone was optimized through careful examination of its determining factors: reflector parameters, feed parameters, and sources of reflection and scattering. Five specific parameters have a significant effect on quiet zone quality:

(1) Feed antenna pattern (see section 2.2.6).

(2) Focal length to diameter ratio (F/D) of the reflector.

(3) Edge geometry.

(4) Distance between reflector and quiet zone.

(5) Reflector size.

For the desired quiet zone field quality and size, the microwave design consisted of a final trade-off between edge geometry and quiet zone size, with the feed antenna pattern, the F/D ratio, and the axial location of the quiet zone as parameters. The goal was to produce a 50-foot diameter quiet zone utilizing the 75-foot diameter circular aperture reflector size that was recommended during the preliminary study (ref 1, app G).

c. The ultimate quality of the quiet zone is specified by the ratio of stray radiation to direct optical radiation within the quiet zone region. Stray radiation produces amplitude and phase ripples in the otherwise constant fields in the quiet zone and is produced by several mechanisms including the following (as shown in figure 5):

(1) Ground reflections.

(2) Scattering by the feed antenna and its support.

(3) Back radiation from the feed antenna.

(4) Scattering from the edges of the reflector surface.

(5) Scattering due to reflector surface roughness.

(6) Reflection and scattering by both the reflector supports and the target positioner supports.

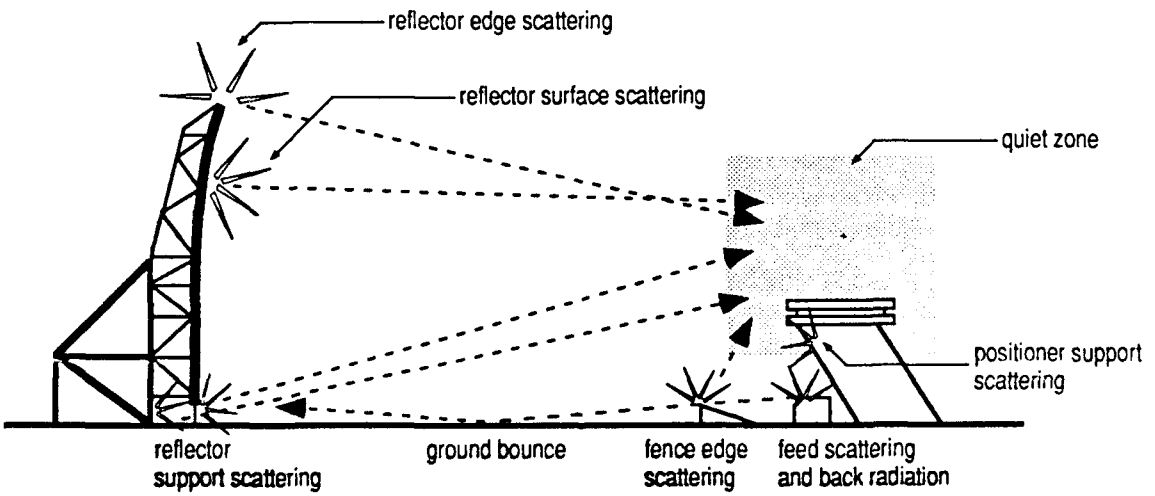

Figure 5. Sources of stray radiation affecting quiet zone quality.

From the beginning, the most difficult problem appeared to be that of adverse effects due to ground reflections. A summary of the causes of stray radiation and their treatments appears in table II.

TABLE II. STRAY RADIATION MECHANISMS

Mechanism	Treatment(s)
Ground reflections	Clutter fence(s). Absorbing panels.
Feed/support scattering	Feed enclosure with absorber.
Feed back radiation	Corrugated horn and feed enclosure with absorber.
Reflector edge scattering	Serrated edge.
Reflector surface roughness scattering	Minimum spatial frequency for surface variations.
Reflector support scattering Target positioner support scattering	Support enclosures and shaping.

f. The design goals were the product of the following factors:

(1) Trade-offs made to achieve the best quiet zone quality.

(2) The accuracy of construction that could be achieved in a reflector of the required size.

(3) Desired performance.

The goal for measurement accuracy was set with the understanding that it is especially sensitive to the level of stray radiation. As noted above, stray radiation due to ground reflections was expected to be one of the most challenging microwave problems to be solved.

g. The overall range concept that was adopted appears in figure 4 (page 2-5). It incorporates a number of key design features:

(1) An offset-fed paraboloidal reflector to minimize the adverse effects of feed blockage.

(2) Serrated reflector edges to control edge scattering and produce a rapid tapering of the aperture field to maximize the quiet zone size.

(3) Tilted support legs on the target positioner supports.

(4) Shaped coverings for the reflector and target positioner supports.

(5) A feed enclosure box to minimize back radiation and scattering.

(6) A ground reflection fence to minimize the level of ground-reflected energy that enters the quiet zone.

Table III presents a list of key microwave design issues that were carefully examined to provide a high quality quiet zone.

TABLE III. KEY MICROWAVE DESIGN ISSUES

Item	Criteria
Focal length (F)	Large F to reduce edge taper.
Quiet zone location (positioner)	Close to reflector to minimize ripple and maximize quiet zone area.
Edge treatment	Taper edge field 30 dB over 10 to 20 wavelengths. Direct edge-diffracted energy out of quiet zone.
Ground reflection	Direct ground reflected feed energy away from reflector and quiet zone.
Panel gaps	Minimize gaps consistent with manufacturing capability (area ratio < 0.0025).
Feed/enclosure	Maximize bandwidth (50 percent). Large beamwidth/minimum edge taper. Prevent feed sidelobes and backlobes from entering quiet zone.
Support Structure Treatment	Redirect reflected feed energy and minimize backscattered energy.

h. Measurements of the dynamic range of the RF instrumentation performed during acceptance testing and preliminary investigations of multipath and clutter signals performed as part of this study indicate that the microwave design issues have been successfully addressed. When a laser-corrected field probe is available, we will perform more detailed studies of the following aspects of the range's design: effectiveness of the reflector edge shaping; effects of reflector smoothness, panel gaps, and panel alignment; and effectiveness of measures used to suppress RF reflections from the ground and support structures.

2.2.1 Quiet Zone Location and Focal Length

a. The optimum location for the quiet zone and the focal length were determined via a trade-off analysis. This analysis was based on computation of the quiet zone fields utilizing aperture diffraction effects only. A trade-off was necessary since the quality of the quiet zone becomes better as the focal length is made longer and as the quiet zone location is moved closer to the reflector. Obviously, it is not practical to have the feed located further from the reflector than the positioner. Tilting the positioner supports forward helps alleviate the feed location problem and minimizes energy reflected into the quiet zone (see section 2.2.5). Through this analysis, the optimum reflector focal length was determined to be 150 feet and the positioner was placed relative to the feed as shown in figure 4. The computer simulation that was used for the trade-off analysis is described below.

b. A computer simulation provided an assessment of the quiet zone field for all of the proposed compact range configurations. The simulation used measured far-field pattern data to model the compact range feed antenna. The feed horn antenna for each band was measured to determine the E-plane and H-plane principal plane patterns. Equations for the main beam shape were developed to match these measurements. The strength of the electric field of the feed antenna is calculated at each point on the reflector surface. The field strength is proportional to the pattern of the feed antenna and inversely proportional to the distance from the feed antenna to the point on the reflector. The field strength is also related to the aiming of the feed antenna. In offset-fed compact range configurations, the minimum amplitude taper is achieved by aiming the maximum of the feed antenna pattern slightly higher than the center of the reflector to compensate for the longer propagation distances associated with the top half of the reflector. The field is reflected from the surface of the reflector using Snell's law for the reflection of plane waves from planar surfaces. The field is propagated a short distance from the reflector to an aperture plane and its amplitude and phase in the plane are recorded. The field at equally spaced points throughout the aperture plane is calculated using this process. The field at each point in the quiet zone is calculated as a near-field integral of the reflector aperture field. The computer simulation was written to be very general in that the various parameters of this offset-fed, point-source compact range can be varied with minimal effort. Such parameters include:

(1) Pattern of the feed antenna.

(2) Location of the feed antenna.

(3) Aiming direction of the feed antenna.

(4) Focal distance of the paraboloidal reflector.

(5) Size of the paraboloidal reflector.

(6) Reflector edge shape.

(7) Smoothness of the reflector surface.

(8) Location of the quiet zone.

c. The parameters of the reflector edge shape will be discussed further in section 2.2.2 below. A panel gap model and a ground reflection model were also developed and added to the basic compact range model. The additional models were necessary to assess the effects of gaps between the finite sized panels used to construct the reflector surface and the effect of ground reflection of the feed antenna radiation onto the reflector and then into the quiet zone. A further model was developed to assess the benefit of diffraction fences and absorber material on the suppression of feed pattern radiation onto the ground.

2.2.2 Reflector Edge Treatment

a. Serrated edges have long been used to reduce edge diffraction effects in compact ranges. The computer simulation described above allowed an optimization of the shape of the edge serration for best quiet-zone performance. The edge serrations were given a generic shape which had the desirable property of continuously varying the scattered field strength from a maximum value at a specified distance from the tip to zero at the tip of each serration. The serrations are cut from the desired paraboloidal surface shape. The optimum reflector edge serration was determined to be a "flower-petal" design consisting of approximately 192 4-foot-long specially shaped petals situated along the periphery of the reflector (see figure 6). The petal shape provides a transition in reflector illumination that is given by:

$$T(r) = (1/2 + 1/2\ \cos(\pi(r-r_{min})/(r_{max}-r_{min})))^{A}$$

where $r_{max}-r_{min}= L$ is the radial length of each serration and A is a non-zero shape parameter. Note that $T(r) = 1$ when $r = r_{min}$ (beginning of the serration) and $T(r) = 0$ when $r = r_{max}$ (tip of the serration), for all non-zero values of A.

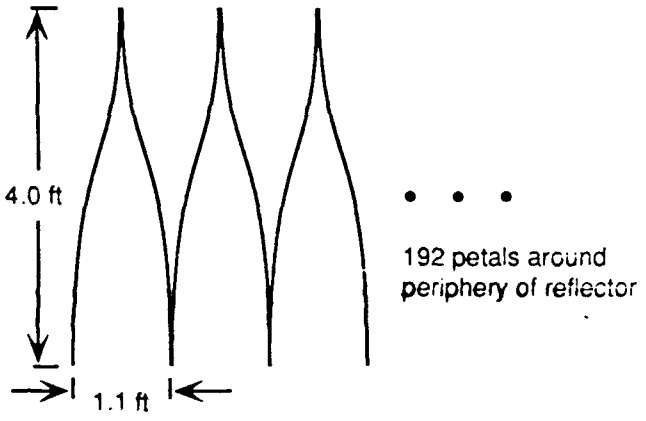

Figure 6. Reflector edge treatment.

b. The serration design has the following variable parameters:

(1) Number of serrations.

(2) Length of each serration.

(3) Shape parameter (A) of each serration.

(4) Width of serration.

c. A large number of analyses were conducted to assess the effects of each of these edge-serration variables on quiet-zone performance. The shape parameter was found to have the greatest effect on quiet-zone performance and has an optimum value of 0.8. The effect of the length of the serration was found to be minimal, if the length is at least 10 wavelengths at the operating frequency. Random serration lengths and widths were tested and found not to improve performance over the easier-to-construct equally sized serrations. The chosen serration length of 4 feet provides a length of over 24 wavelengths at the lowest design frequency of 6 GHz. The serrations are even longer electrically at the higher frequencies. Detailed results of this optimization process are presented in references 4 and 5 (app G).

2.2.3 Ground Reflection Suppression (Feed Fence)

a. The initial fence design incorporated a single fence with a straight edge. Diffraction analysis and subsequent antenna range tests showed that the fence greatly reduced the amount of feed energy striking the ground between the feed and the reflector. However, a significant level of energy was diffracted by the edge of the fence producing feed-pattern amplitude ripples on the order of ± 1.3 dB in an angular region that would be intercepted by the reflector surface. Such ripples would be detrimental to the overall performance of the compact range.

b. The second fence design incorporated petal-shaped serrations similar to those utilized on the reflector edge. The level of feed energy that was diffracted directly from the edge of the fence into the quiet zone was reduced by the action of the petals in tapering the diffracted field. However, diffraction analysis showed that the reduction was not significant enough to warrant the increased complexity. The pattern ripple varied between ± 1.0 and 1.5 dB depending on the particular configuration analyzed. The computer simulation results for the serrated fence tops, although not significant for compact range usage, were applied to far-field range fences with good results. This work is described in reference 4, appendix G.

c. Further analysis indicated that either multiple, short, absorbing fences or a single absorbing fence with a relatively long absorber layer (on the order of 30 feet) separating it from the feed (see figure 7) should work much better than the diffraction fence designs. However, both approaches would have incorporated large amounts of absorber exposed to sunlight, moisture, and mechanical damage. An undesirable level of maintenance would have been required.

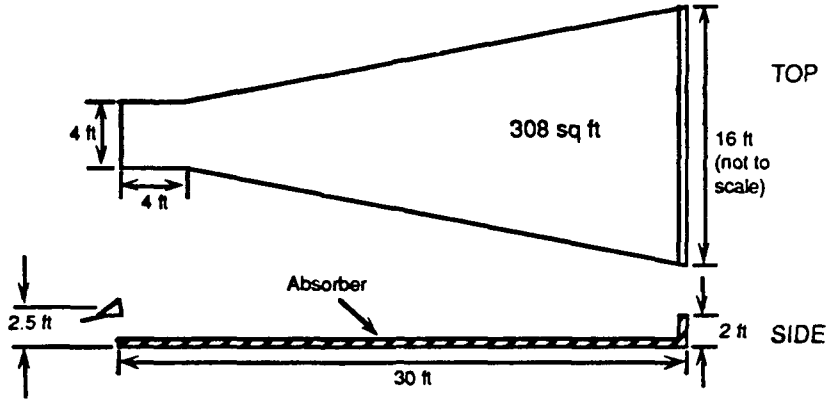

Figure 7. Non-preferred reflection fence configuration.

d. The subsequent approach used the straight-edge fence with a rolled edge added to negate the edge diffraction. Since it was expected that the rolled edge would scatter too much energy forward into the reflector, a thin, painted-on absorbing epoxy layer was added to the rolled surface in an attempt to reduce the surface currents. This surface-wave absorber approach was not successful, but the application of a layer of standard convoluted foam absorber gave relatively good results. This was the approach taken in the initial fence installation. However, during RF testing the rolled edge did not perform to expectations. Absorber was applied to the existing fence and the front part of the rolled edge was removed. This configuration, shown in figure 8, was used during the field probing and acceptance tests. This configuration appears to work well; however, when field probing of the entire quiet zone is performed with a precision field-probe, adjustment may be required.

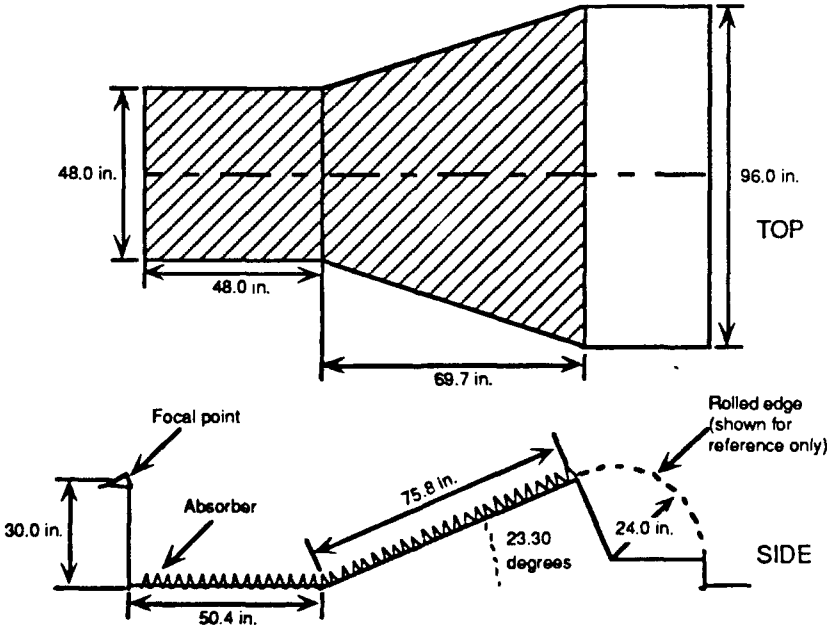

Figure 8. Final ground reflection fence configuration.

2.2.4 Reflector Panel Gaps

The panel gaps were specified to provide a ratio of gap area to panel area of no more than 0.0025 within the 32-foot radius zone of the reflector. This specification provides a pattern ripple within the quiet zone due to the panel gaps of less than ± 0.4 dB. It is achievable within the constraints of the reflector mechanical design and tolerance specifications (per discussions with reflector manufacturers). Additional analysis of the effects of gaps on compact range performance was conducted using an aperture model for each of the many reflector gaps. This model is a function of polarization and frequency, unlike the gap area model described above. This improved model shows that gaps have minimal impact on electric fields parallel to the gaps, and that such scattering increases with gap width and frequency. The significant scattering by gaps is via scattering of the fields perpendicular to the gap. This cross-polarized scattering is found to increase with gap width but decrease with frequency. The worst case for this scattering occurs at the low frequency limit of 6 GHz where an RMS average of ± 0.18 dB quiet zone ripple is predicted for 0.060-inch gaps. Details of this analysis and the results are provided in reference 6 (app G).

2.2.5 Support Structure Treatment

a. The positioner's leg structures are designed for minimum impact on quiet zone field performance. The legs are sheathed in forward-leaning ogival shells. The ogive radius used in the design ensures that any electromagnetic energy traveling from the reflector toward the quiet zone and positioner, parallel to the range axis, will not be reflected back toward the reflector (see figure 9); that is, the energy passing between the two towers may undergo multiple reflections from one tower to the other but will continue in a down-range direction. The forward 20-degree tilt angle of the positioner legs was chosen to ensure that specularly reflected energy from the front edge of each of the shells is directed downward, away from the quiet zone. The angle of tilt is such that the downward directed energy strikes the ground and is then reflected upward and over the top of the reflector, ensuring that this energy will not be reflected into the quiet zone. Leading edge scattering which is directed downward and to the side is also directed away from the compact range reflector.

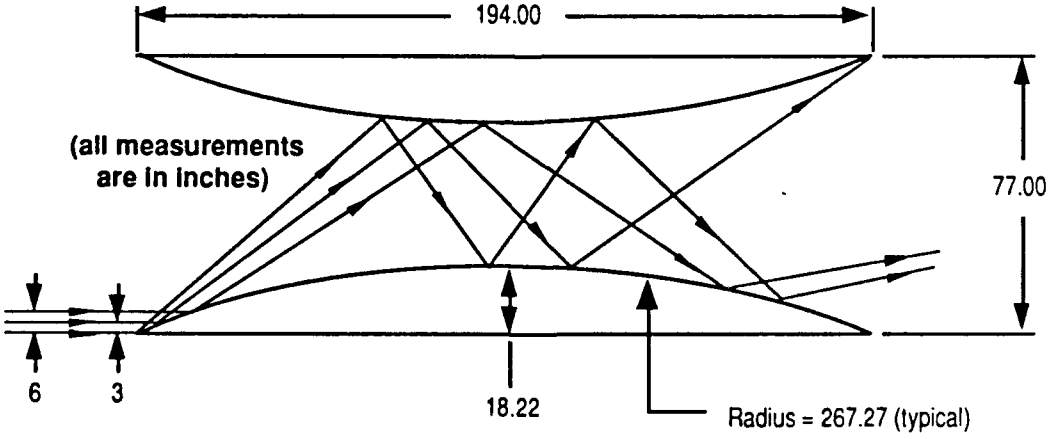

Figure 9. Interior of positioner support leg.

b. Similar shells were applied to the portions of the reflector support structure that are visible to the incident radiation from the feed horn. The geometry of these shells causes energy to be directed away from the quiet zone, even after as many as two reflections.

2.2.6 Feed Design

a. The initial design for the feed horns was established in an earlier report (ref 3, app G). The initial design in the report covered only frequencies from 8 to 12 GHz. In order for the feeds to cover the required range of 6 to 40 GHz, the feeds were scaled to cover a total of five frequency ranges: 6 to 8, 8 to 12.4, 12.4 to 18, 18 to 26.5, and 26.5 to 40 GHz. The feeds were required to have a small feed pattern taper over the illuminated reflector.

b. The feeds have the following specifications:

(1) Bandwidth: 50 percent.

(2) Gain/3-dB beamwidth: 10 dBi/40 degrees.

(3) Polarization: Linear.

(4) VSWR: 1.2:1.

c. The feeds are made of brass and have internal corrugations as shown in figure 10. A detailed drawing of the C-band feed appears in figure 11. Each feed is attached to an individual base. Each combination of feed and base has been phase matched, putting the phase center at the same location. This permits the feeds to be interchanged in the feed enclosure without having to realign the feed system.

d. The feed mount and positioner are located inside the feed enclosure (see figure 12). The enclosure has a front window and radome of teflon-treated fiberglass that allows the feed to radiate from inside the enclosure. RF absorbing material surrounds the feed to help control stray radiation. The enclosure is made so that the entire front can be opened to change the feeds. A weather cover can be closed over the radome to keep out rain and dust.

e. The feeds are mounted on a flat plate that forms a part of the feed positioner. The positioner uses a parallelogram linkage that positions the phase center of each feed at the same location. The linkage permits the feed to be rotated about the phase center without displacing or translating the feed. The feed mount is positioned so that the phase center coincides with the focal point of the reflector.

f. As previously described, the center of the feed horn points slightly above the center of the reflector (see figure 13).

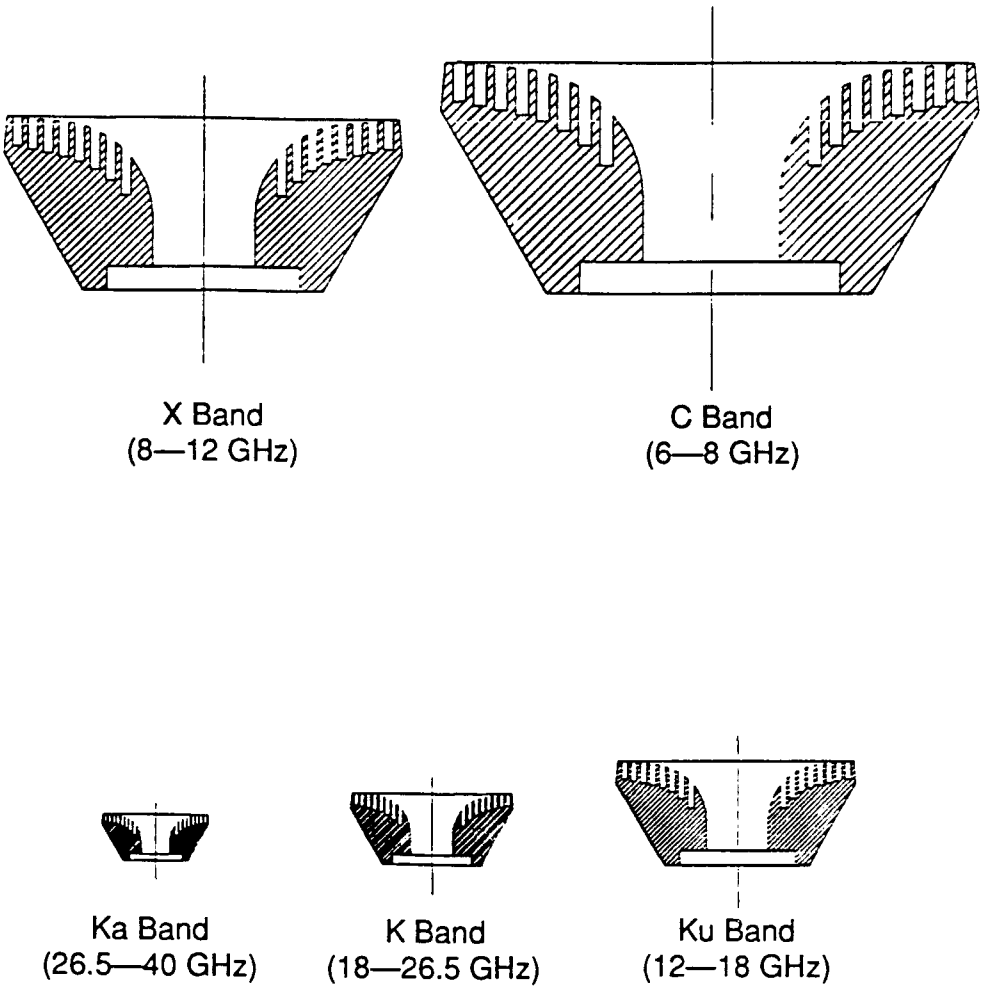

Figure 10. Compact Range feed horns.

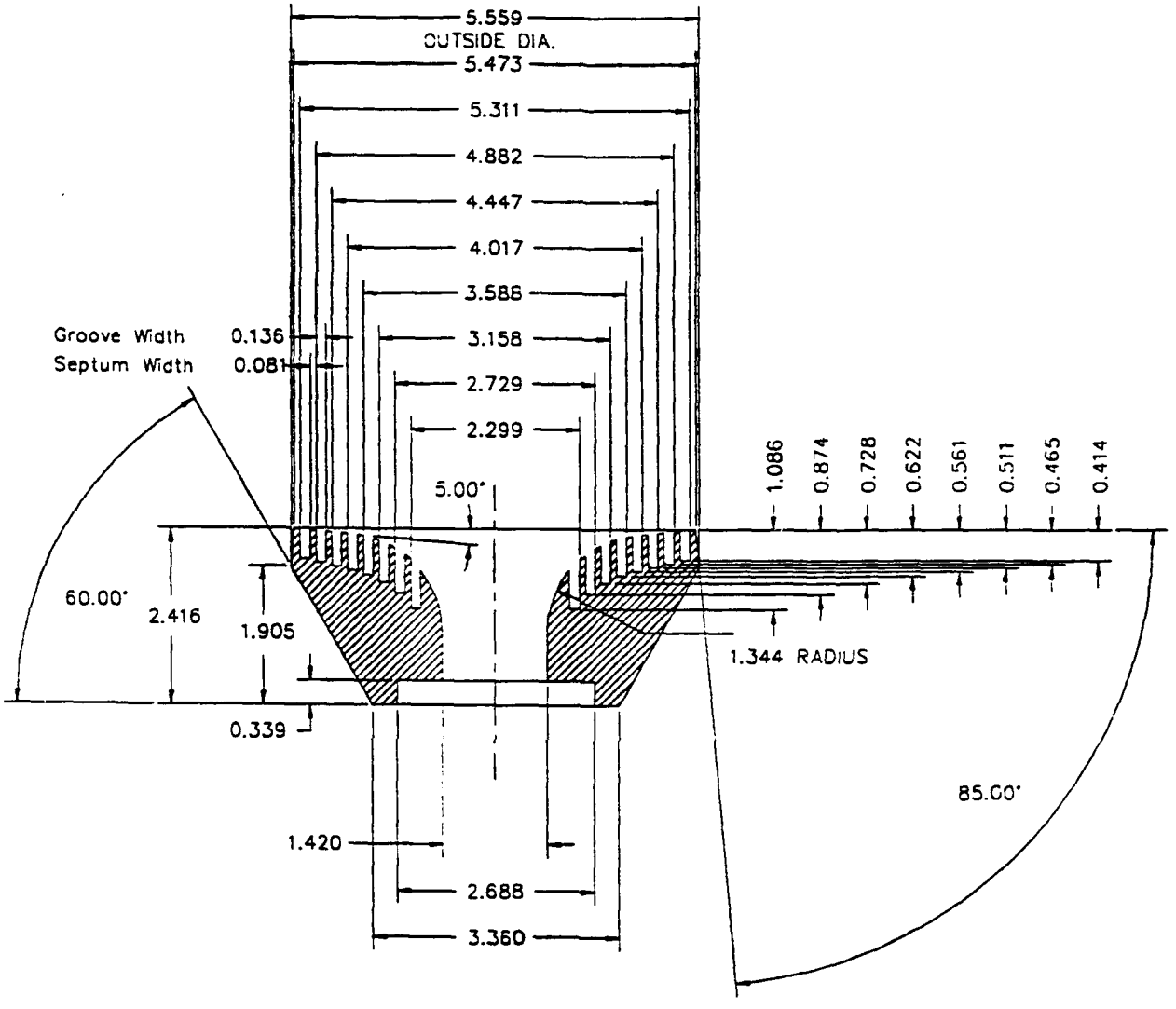

Figure 11. C-band horn.

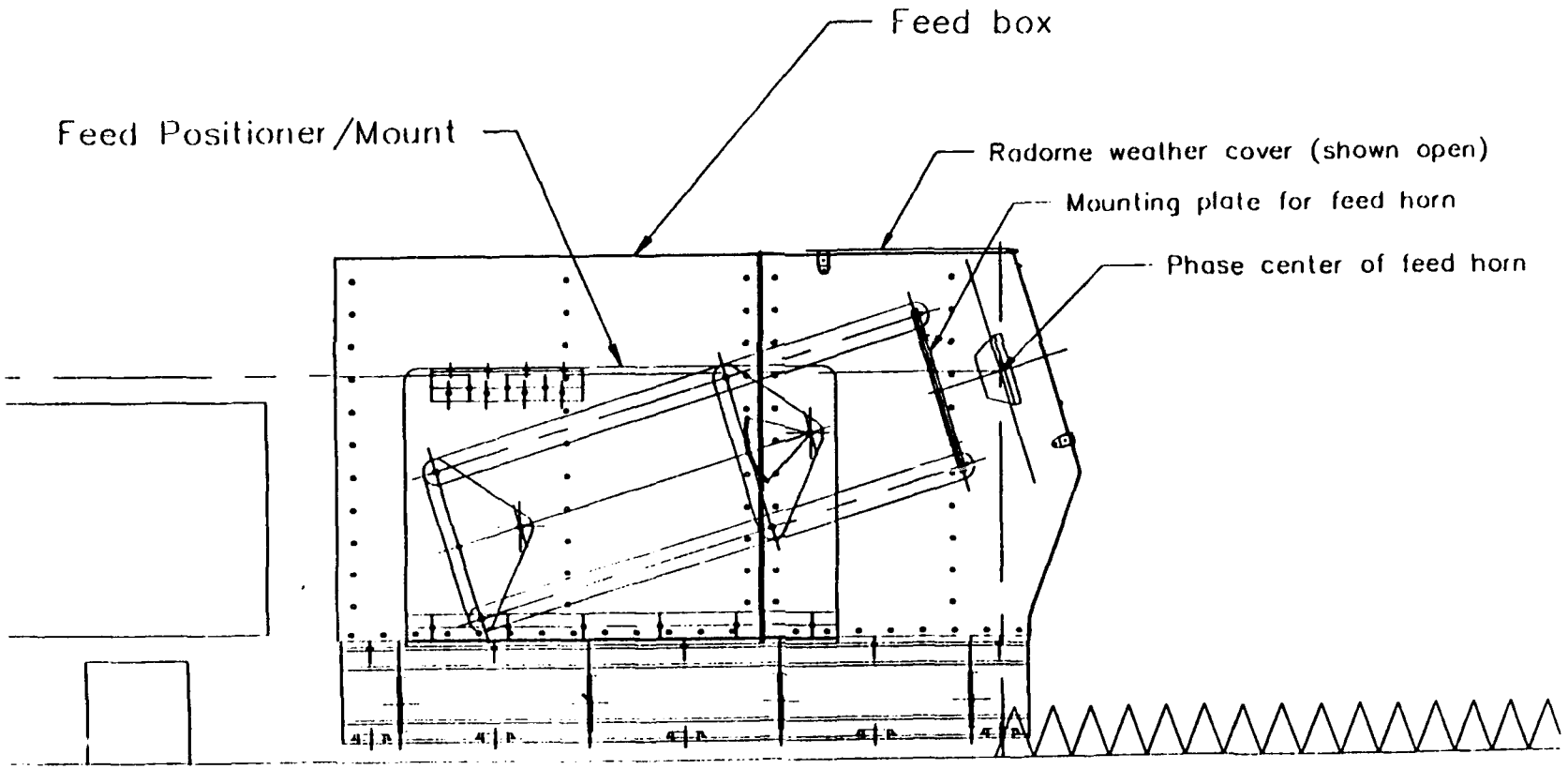

Figure 12. Feed enclosure.

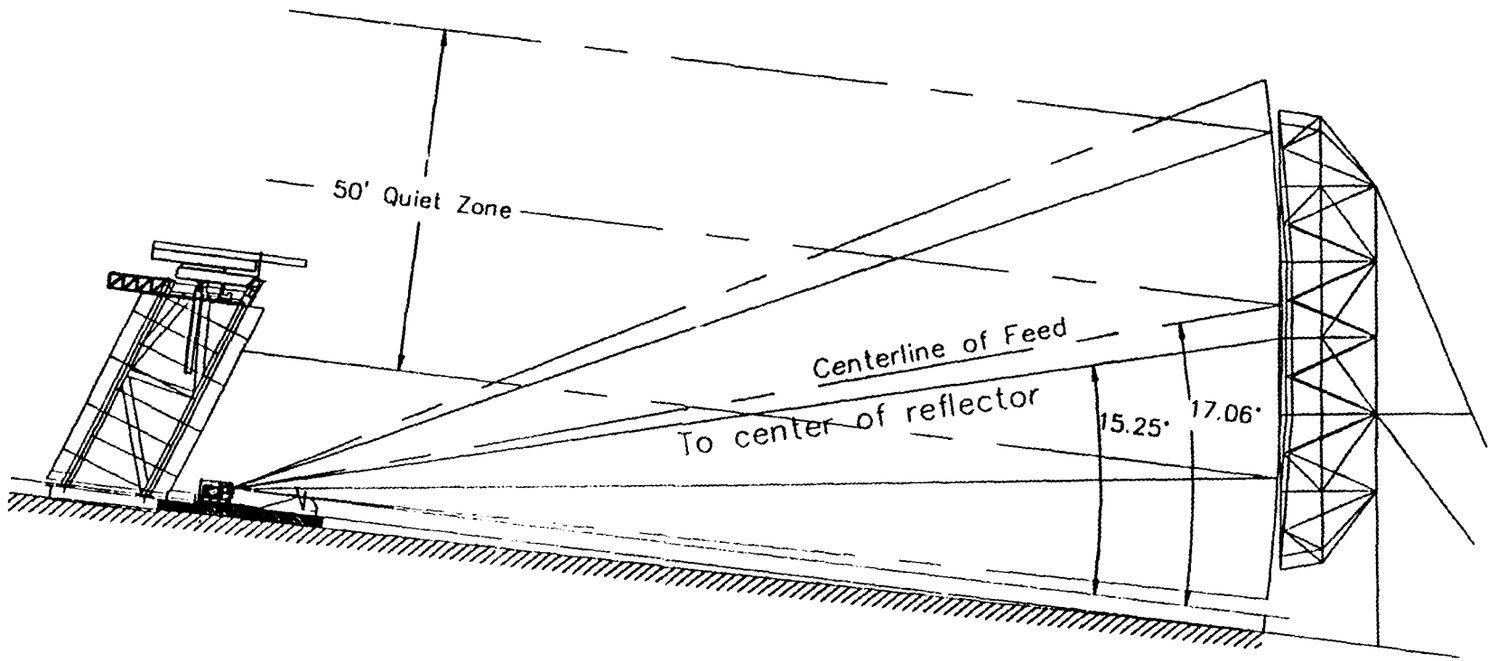

Figure 13. Pointing of feed horn.

2.3 POSITIONER DESIGN

a. The positioner's basic configuration appears in figure 14. The tower is composed of two parallel plane I-beam frames, joined at the top. These frames support the hinges about which the tilt table pivots, and the trunnions of the hydraulic cylinders which drive the tilt table. The tilt table carries the turntable bearing. The target antenna or vehicle is mounted to the turntable, which is driven by a hydraulic motor. The turntable/tilt table arrangement creates an azimuth-over-elevation positioner. Azimuth travel is unrestricted. Nominal elevation range is -1.40 degrees to +90.63 degrees. The positioner provides full hemispherical coverage of the target.

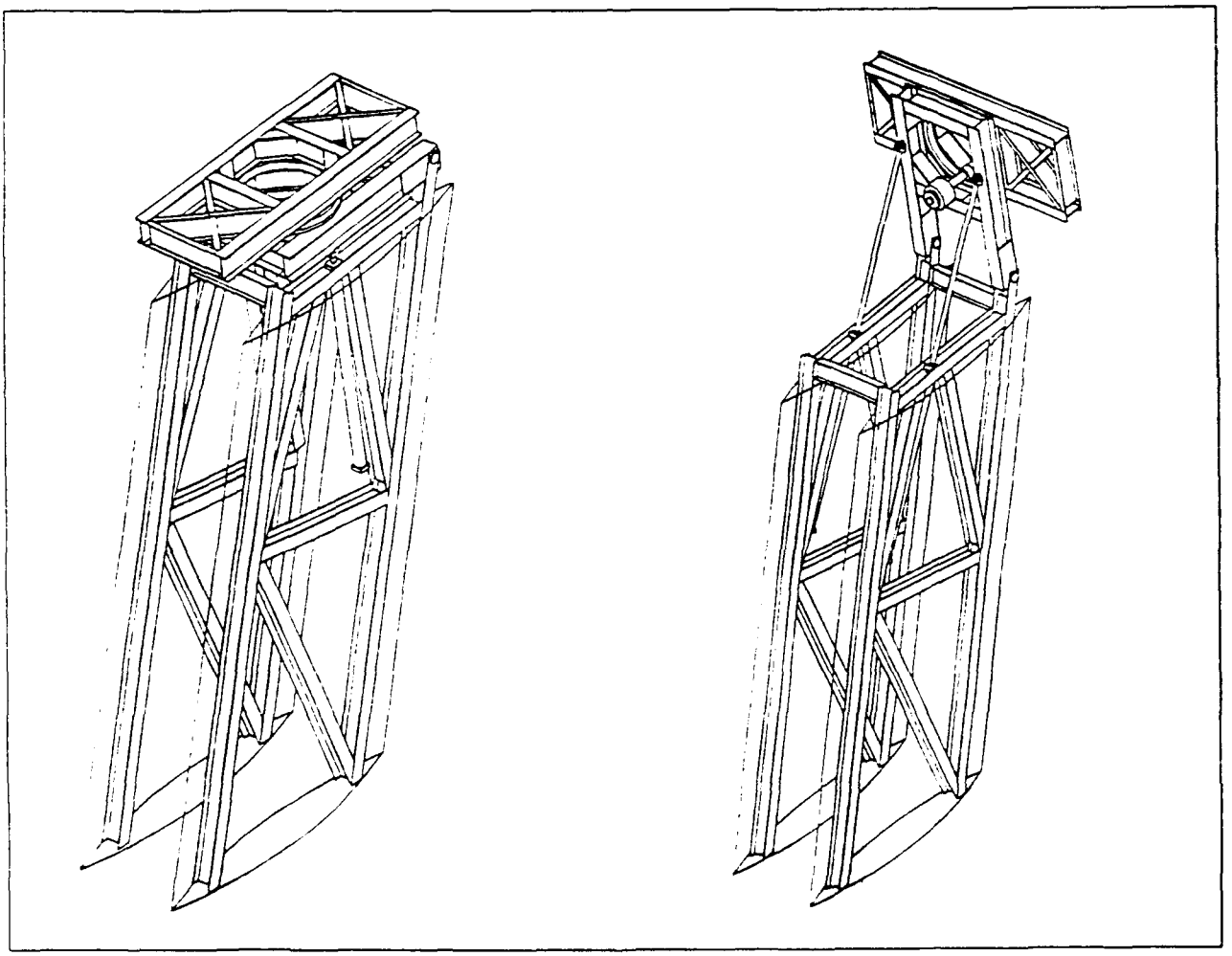

Figure 14. Positioner at 0 degrees (left) and 90 degrees (right) of elevation.

b. The positioner can handle vehicles weighing up to 140,000 pounds (70 tons). This capacity allows mounting a wide variety of vehicles, aircraft and antennas, including the M1 Main Battle Tank, Bradley Fighting Vehicle, 2-1/2 and 5-ton trucks, and OV-1 aircraft. These vehicles can be securely mounted, using special brackets to interface to the turntable. Mounting an M1 tank required removing six road wheels and suspension units. The brackets bolt to the tank's suspension mounting surfaces and to plates bolted to the outside perimeter of the turntable. The tracks straddle the turntable.

c. The size of the target is limited by the need to keep all significant portions of the target within the quiet zone as the positioner moves. Ideally, any point of interest remains inside the quiet zone. There are no excursions outside the quiet zone for radii up to 20 feet, at heights up to 18 feet. There are minor excursions (20 inches or less) for a 25-foot radius at heights up to 12 feet. Permissible heights and radii are shown graphically in figure 15. Most systems of interest can be mounted so that all major features remain in the quiet zone.

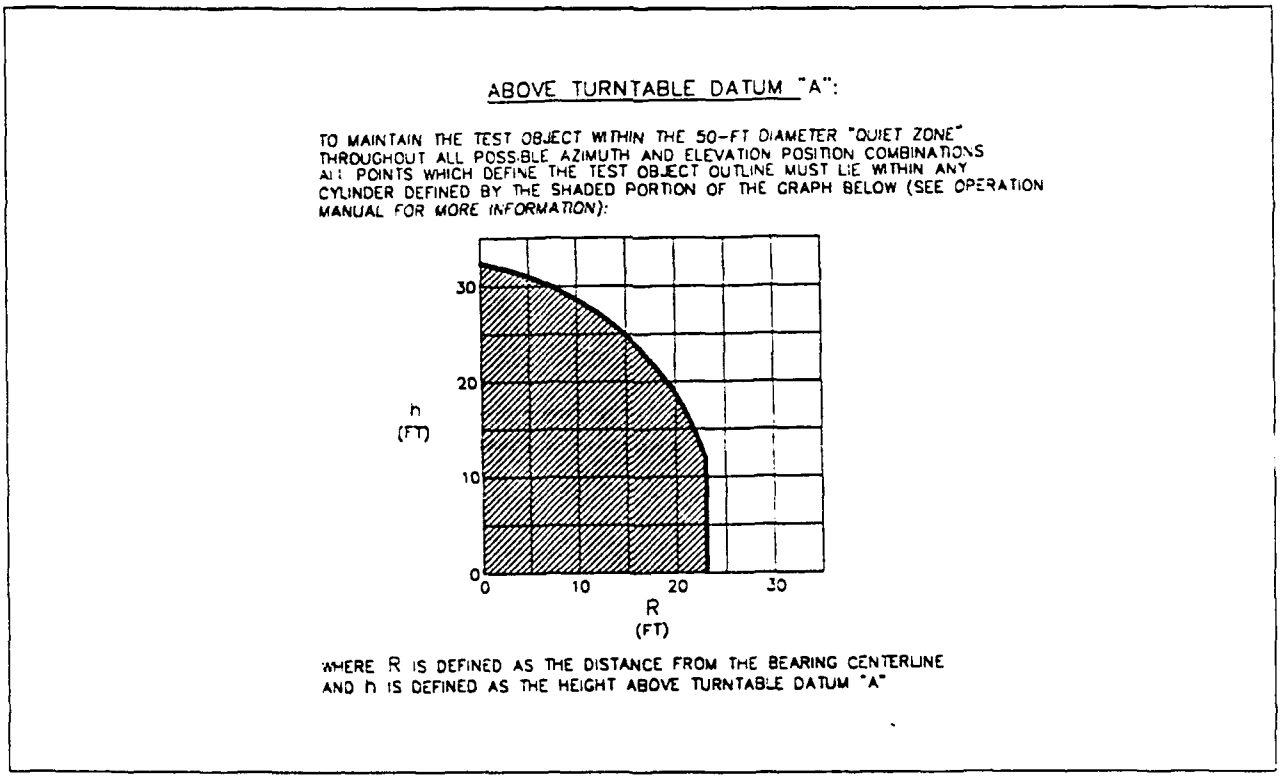

Figure 15. Permissible size of test item to stay within quiet zone.

2.3.1 Hydraulic System

a. Test range positioners are usually driven by electric motors. However, a hydraulic drive was chosen for the USAEPG Compact Range in order to satisfy several design requirements including heavy loads, high speeds, space restrictions, and low backlash. The need for accurate speed control over a wide range of loads and geometries led to a servo system with velocity feedback. The hydraulic system is divided into several major units: the hydraulic power unit (HPU), hydraulic control unit (HCU), two elevation cylinders, and azimuth motor. The cylinders actuate the elevation axis; the hydraulic motor actuates the azimuth axis. The simplified schematic of the hydraulic system is shown in figure 16.

b. The HPU is housed in the underground equipment enclosure immediately behind the positioner. A 40-horsepower (hp) electric motor drives a variable displacement piston pump. The pump's operating limits are 45.7 gallons per minute (gpm) and 3000 pounds per square inch (psi). The pump is pressure-compensated and horsepower-limited. The pump displacement varies to hold output pressure at 3000 psi as long as the required power does not exceed the electric motor's capability. The pump output, modulated by electrically controlled jet pipe servo valves, drives either the azimuth motor or the elevation cylinders. The two axes do not operate simultaneously.

c. An auxiliary pump, powered by a 5-hp electric motor, provides flow to the filter and cooler. In addition, it is designed to operate the positioner (at substantially reduced axis speeds) in case of main pump/motor failure or main power outage (with emergency power).

d. The HCU is located on the rear work platform, or balcony, of the positioner. It includes a manifold block, filter, shutoff valve, solenoid-operated axis select valve, and servo valves. The axis-select valve supplies high-pressure hydraulic fluid to the appropriate servo valves.

e. The turntable is driven by the azimuth motor through a pinion/internal gear mesh. The motor torque is amplified by the 6:1 gear ratio, providing up to 113,000 foot-pounds to the azimuth axis. The turntable maximum speed is approximately 15 degrees per second (2.5 rpm). Backlash is set to 0.01 degrees. Motor overhauling loads are controlled by counterbalance valves. Maximum pressures are limited by cross-port pressure relief valves. The azimuth axis has a hydraulically released spring-applied disc brake to prevent drifting when the motor is not under active control.

f. The two identical elevation axis cylinder units are trunnion-mounted within the tower structure. The cylinders receive hydraulic fluid at equal pressures and exert approximately equal forces on the tilt table (the tilt table mechanically synchronizes the cylinders). The cylinders have 8-inch bores, 4.5-inch diameter rods, and 11.5-foot strokes. Each is capable of 145,000 pounds extension and 99,000 pounds retraction forces. The positioner can move the 140,000-pound design load through the full range of elevation travel with no measurable backlash. Maximum elevation axis velocity is approximately 0.7 degrees per second.

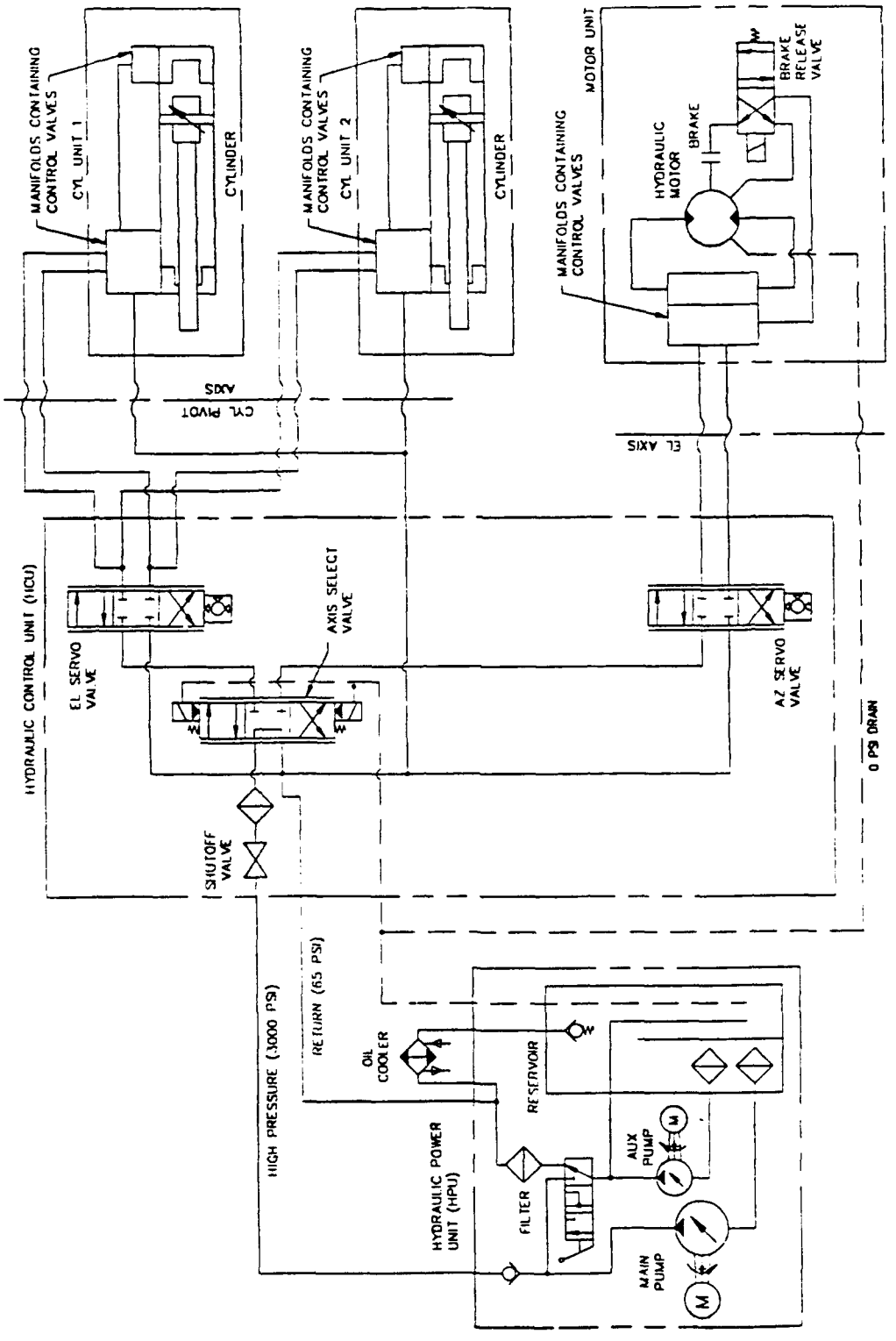

Figure 16. Hydraulic drive system schematic.

g. Manifolds containing counterbalance valves, flow-limiting valves and cross-port pressure relief valves are bolted to the upper head blocks of each elevation axis cylinder. Manifolds containing flow-limiting valves are located likewise on the lower head blocks. The counterbalance valves prevent uncontrolled retraction or extension of the cylinders so a plumbing failure will stop all positioner motion. Overhauling loads are also controlled by the counterbalance valves. Flow-limiting valves keep the maximum cylinder speed within safe limits. Potential pressure spikes from rapidly closed hydraulic valves are prevented by cross-port pressure relief valves. Cylinder cushions limit elevation travel. During the end of the stroke, a tapered plug attached to the piston progressively restricts flow from the cylinder, bringing the piston to a smooth stop. Hydraulic cushions can safely stop the load even when the elevation limit switches have been overridden electrically.

h. As a result of this study and the investigation of the hydraulic system's behavior under near-maximum weight and inertial loading, some modifications were deemed necessary in order to avoid overstressing the vehicular mounts and positioner azimuth bearing. They consisted of the addition of a low-pass filter, modifications to the control software, and adjustment of the gain of the azimuth rate servo loop. These modification were designed to prevent oscillation of the test item, and to reduce the maximum rates of acceleration and deceleration in the azimuth axis. These modifications successfully limited undesirable movements of the tank and aircraft test loads used during this study.

2.3.2 Structure

a. The tower carries gravity loads (from the elevation pivots and hydraulic cylinders) as an independent pair of plane frames. These frames are rigidly anchored to the foundation at the base, and are rigidly joined at the top. This allows lateral (wind) loads to be shared by the two frames, each carrying bending moments at the top and bottom. The frames have internal clearance through which the elevation cylinders swing. The tilt table and turntable provide very stiff, flat mounting surfaces for the azimuth bearing. The four-point contact, combined load bearing has an internal spur gear cut into the inner race. This race, bolted to the turntable, is driven by a hydraulic motor and pinion.

b. The positioner structure was analyzed by an independent consulting firm. The analysis used various combinations of wind, gravity, and seismic loads at various azimuth and elevation orientations to determine the stress in the structure. Also, a natural frequency analysis was performed to predict dynamic characteristics for various elevation angles and load conditions.

c. Several design features suppress scattering or reflection of energy into the test volume. The tower is tilted 20 degrees toward the reflector; bracing between the tower legs was omitted; ogive-shaped shells were placed around the tower legs (see section 2.2.5 and figure 9, page 2-13); and a radar absorbing material (RAM) panel was installed in front of the elevation axis. These features appear in figure 17. More precise field probe data will be necessary to determine the effectiveness of these suppression techniques.

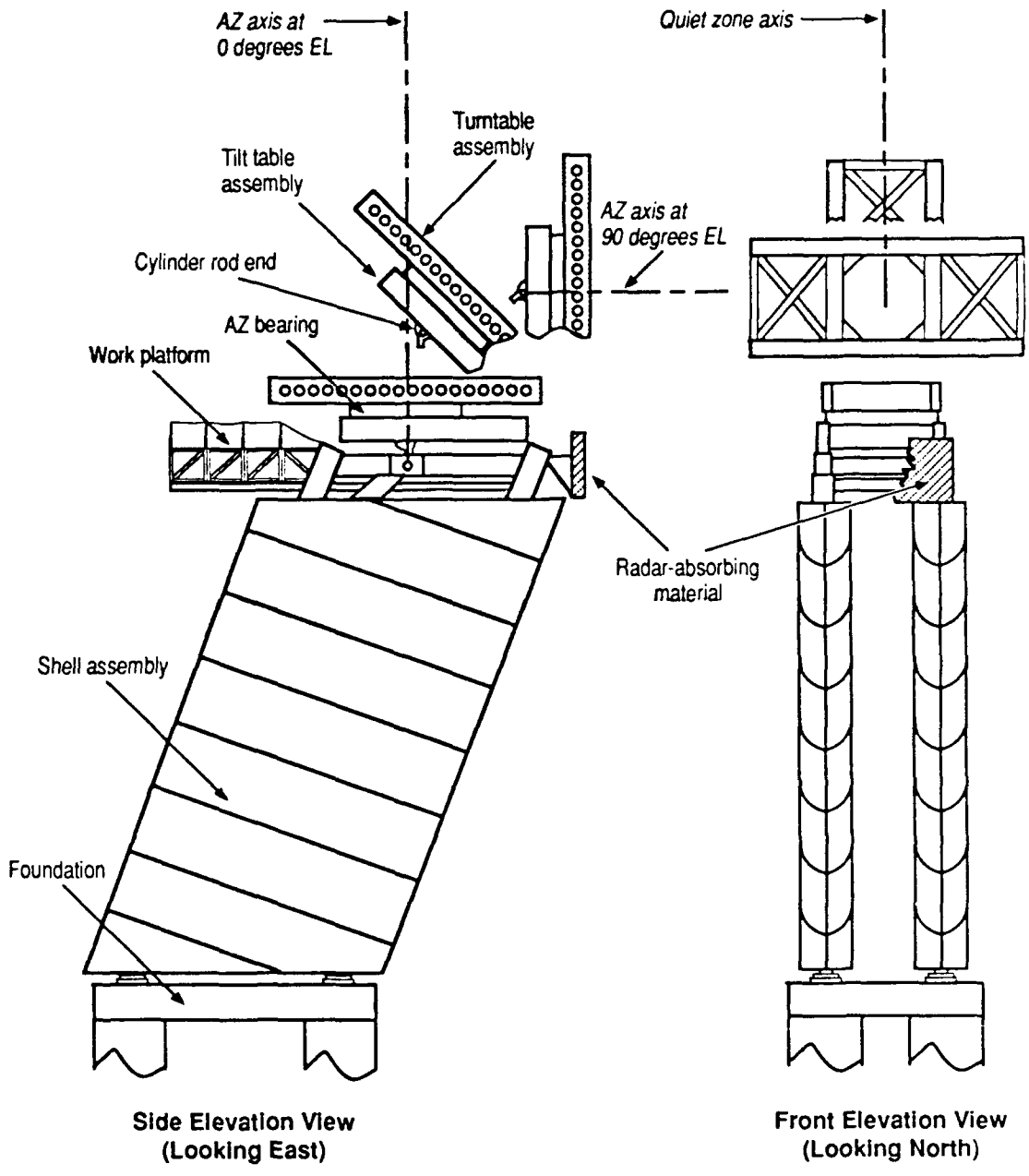

Figure 17. Compact Range positioner.

d. Figure 18 is taken from GTRI drawing 39224010, "Interface Requirements, Vehicle-to Turntable." The top and sides of the turntable have clearance holes for 1-inch bolts to facilitate mounting targets. Mechanical clearance requirements are delineated. A simple graph of target height and radius (figure 15, page 2-20) determines whether a target will stay inside the quiet zone as the positioner axes move.

e. The elevation moment (M_{el}) imposed on the positioner by the target at 90 degrees is:

$$M_{el} = W \times Z_{cg}$$

Where W is the total load weight on the turntable and Z_{cg} is the horizontal (at 90 degrees) distance (moment arm) between the load's center of gravity and the elevation axis. M_{el} must not exceed 10.22×10^6 inch-pounds, or 8.52×10^5 foot-pounds.

f. The azimuth offset moment is the maximum moment imposed on the turntable drive by the target as an off-center load when the elevation axis is at 90 degrees. It is defined as:

$$M_{az} = W \times R_{cg}$$

W is defined above. R_{cg} is the distance between the load's center of gravity and the azimuth axis of rotation. M_{az} must not exceed 1.04×10^6 inch-pounds or 8.67×10^4 foot-pounds.

Exceeding either moment limit may stall the hydraulic drive. Figure 18 shows a generic test load and defines R_{cg} and Z_{cg}.

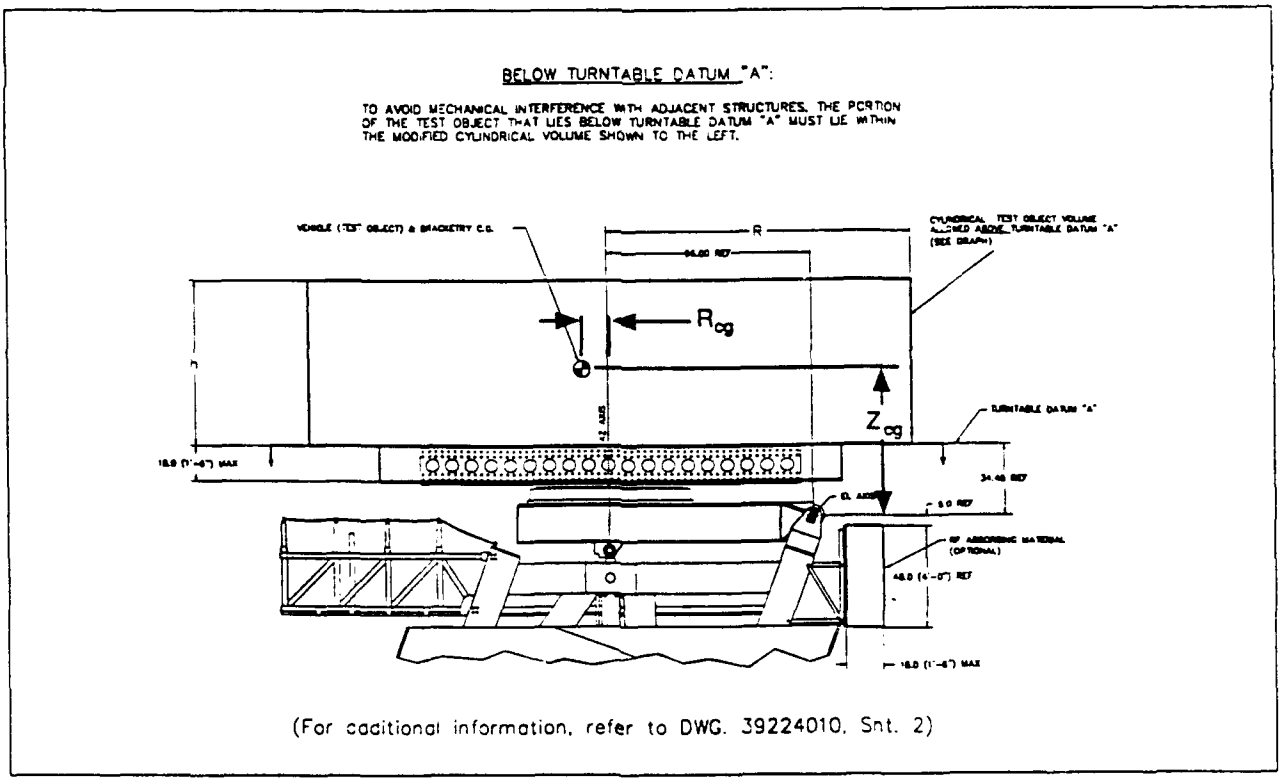

Figure 18. Mechanical clearance requirements.

2.3.3 Foundation

a. The positioner foundation is reinforced concrete. It includes a mat, four caissons, a multitude of reinforcing rods and 48 threaded anchor rods (12 per tower leg member). The design of the foundation was based on the positioner structural analysis and borings and soil tests at the positioner site.

b. The grade-level mat measures 10 feet 5 inches wide by 15 feet 8 inches long by 4 feet deep. The mat ties together the four caissons. The caissons are 4 feet in diameter and 35-foot deep, with centers at 11 feet 8 inches fore and aft and 6 feet 5 inches side-to-side. The caisson's tensile strength is provided by full-depth steel rod cages. The anchor rods transfer their loads into the cages through the concrete. The anchor rods, 1-1/2 inches in diameter and 5 feet 1 inch long, were supported during the pour by a precision template and allowed to protrude 8 inches above the mat to secure and level the positioner.

2.3.4 Shells

a. The shells are ogive-shaped devices that reduce the effect of electromagnetic scattering from the positioner on quiet zone quality. They cover almost all of the two parallel-plane I-beam frames. The shells are composed of 48-inch wide panels riveted to leading and trailing edge extrusions. The panels have reinforcement ribs every 16 inches (see figure 9, page 2-13 and section 2.2.5).

b. Two types of analysis were performed in designing the shells. A ray tracing analysis was done to ensure that all the microwaves passing the leading edges are reflected so that they do not interfere with testing. Since the entire structure is tilted at 20 degrees with respect to vertical, the microwave energy that hits the leading edges is reflected with minimal interference. A stress analysis was also performed to ensure that the structure would support its weight and withstand a 100-mph wind. This stress analysis did not include buckling. A test fixture was used to test a sample of aluminum sheet metal for buckling. The sample was 48 x 48 x 0.060 inches with plywood bulkheads every 16 inches simulating reinforcement ribs. Wind was simulated by piling sand on top of the sample and an axial load simulating the weight of the structure was applied using springs. The test demonstrated that the shells would not buckle.

2.4 ELECTRONIC DESIGN

a. The purpose of this section is to provide an overview of the Compact Range electronic design. The RF instrumentation and computer systems are located in four separate locations (as seen in figure 2, page 2-2):

(1) Operations trailer (range control room) next to the Arc range.

(2) Underground equipment shelter behind the positioner.

(3) RF electronics enclosure behind the feed box.

(4) Top of the positioner.

b. All locations are interconnected by various electrical, RF, and fiber optic cables. A functional block diagram appears in figure 3, page 2-3. The controlling software uses a standard IEEE-488 interface with the range instrumentation and general purpose input and output (GPIO) boards to monitor and control the range. The input board is interrupt-driven and the interrupt service routines maintain a set of real-time status variables which are checked before commanding positioner motion. If an item being monitored requires immediate operator action, the interrupt service routine returns control immediately to the operator. The monitored items include "panic" switches (switches that allow emergency range shutdown), axis limit override switches, and the status of the hydraulic filters.

c. The Compact Range is operated from the control room where the computers and Flam and Russell 8502 positioner controller are located. An HP 8510B is situated 350 feet away (in terms of control cable length) in an underground equipment enclosure and is operated in the remote-mixer/dual-source mode. The system's RF source is located immediately behind the feed while the local oscillator (LO) source is located on top of the positioner tower. Besides the HP 8510B, the underground equipment enclosure houses the hydraulic interface unit and the tachometer servo unit, both developed and produced by GTRI. A Scientific Atlanta 4180 SCR unit is located on the positioner tower to allow use of either a standard positioner or other unit (e.g. field probe).

2.4.1 Electronic-to-Hydraulic Interfaces

a. The hydraulic interface unit (HIU) was designed to allow the hydraulic positioner to operate using standard antenna positioning systems. A tachometer servo unit (TSU) was required to allow accurate monitoring of the hydraulic elevation axis. The HIU was designed to incorporate a dual-axis hydraulic positioner into the existing protocol used by commercial antenna positioner controllers. The USAEPG Compact Range could not use a standard axis driver/controller configuration because the hydraulic axes required current actuation (servo valves) rather than voltage actuation (dc motors) normally used by conventional positioners.

b. The HIU performs two primary functions; it serves as the axis select decoder and as the axis velocity and limit controller. The HIU monitors the axis select lines originating from the Flam and Russell 8502 Positioner Controller to determine which axis is being addressed. If an auxiliary axis is selected (axes C, D, E, F), the HIU becomes transparent to the system and the system behaves as a typical positioner using the Scientific Atlanta 4180 SCR unit as an axis driver/controller. If a primary axis is selected [i.e. hydraulic azimuth (axis A) or hydraulic elevation (axis B)], the control signals are passed on to the HIU circuits.

c. The internal circuits of the HIU are a hybrid of GTRI and Scientific Atlanta engineering. Modified versions of the Scientific Atlanta limit and rate control circuitry are used in conjunction with circuit boards developed by GTRI. The GTRI boards furnish the interface to the hydraulic axes by providing closed loop velocity control and position limit control of the axes. The custom printed circuit boards also convert the drive voltage into a proportional direct current required to drive the servo valves for both hydraulic axes.

d. The tachometer feedback system used for closed loop velocity control of the axes varies with each axis. Tachometer feedback for the azimuth axis is provided by a conventional gear train linked directly to the axis. The slow speed of the elevation axis prevented turning the tachometer directly from the elevation axis. A tachometer feedback signal for the elevation axis is provided by the TSU. The TSU uses an electromechanical technique to multiply the velocity of the elevation axis by using a servo loop which follows a synchronizer transmitter mounted to the axis. By using a high-speed motor mounted in the TSU chassis and turning a dc generator, a higher voltage level is produced for the necessary speed of the elevation axis.

e. The hydraulic drive is controlled by a servo with velocity feedback. The block diagram appear in figure 19. In the automatic mode, the programmable position controller receives position information from the synchronizers and generates a velocity command. In the local mode, the velocity command comes from a hand-held local controller. The servo control compares the velocity command to the tachometer feedback, generating milliampere signals to control the hydraulic servo valves. These valves regulate flow to the cylinders and motor. The servo control is designed to interface directly with commercially available equipment that might be used on the range. This gives the added flexibility of using an additional positioner attached to the turntable (e.g.,field probe).

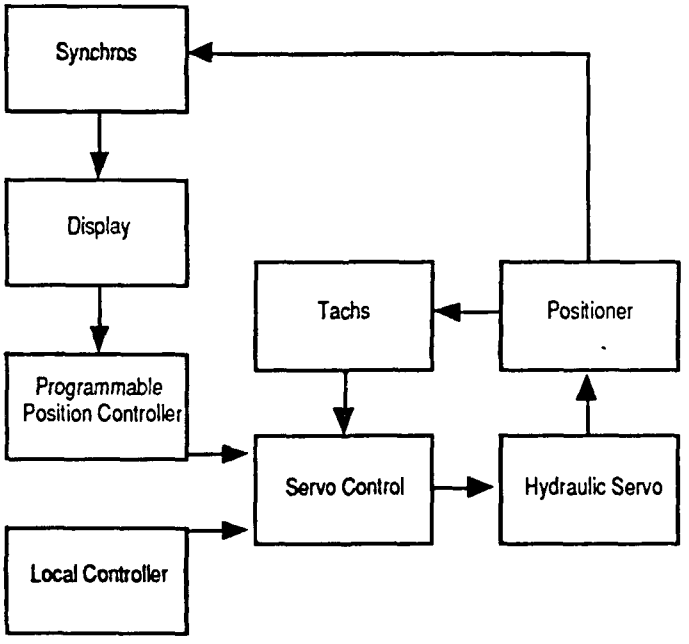

Figure 19. Block diagram of positioner control functions.

2.4.2 Slip-Ring Package

In addition to the RF rotary joints on the positioner turntable provided to route the LO and mixer signals to the antenna under test, a slip ring package is included. These slip ring contacts are primarily designed to allow mounting an auxiliary positioner on top of the positioner platform. These contacts could also be used to route low-frequency signals to/from the system under test.

2.4.3 Computer System

a. The Compact Range is completely automated and is based on a multiple-process, dual-computer design using a VAX 11/751 and a Micro VAX GPX Workstation. The VAX 11/751 is the processing computer where all I/O and CPU intensive tasks such as test creation, plotting, and data analysis are performed. The Micro VAX executes the test and collects the data for transmittal to the VAX. These two units are connected by Ethernet communications (DECnet). Use of the DECnet requires that the computers be assigned node names. These node names are sometimes used to refer to the computers themselves. The node name for the VAX 11/751 is EAGLE. The node name for the compact range Micro VAX Workstation is HAWK. In the event of VAX 11/751 failure, control and data processing can be handled by the Micro VAX computer at reduced performance.

b. The computer software is designed for automatic acquisition of antenna amplitude and phase data. In addition, it has analysis algorithms to evaluate the measured antenna data as well as specialized plot routines. The size and configuration of the Compact Range presented several distinctive challenges for software development. Some of these were the need to: (1) remotely monitor and control equipment whose configuration and presence varied with the frequency band, (2) operate the HP 8510B remotely, and (3) provide a method for handling positioner overspeeds without operator action.

c. An overspeed event occurs when the positioner arrives at a data collection increment before the rest of the system has finished acquiring data from the last data collection increment. When this occurs, the Compact Range positioner system will reposition to the last completed data point and continue. If an overspeed happens within the first few points of a scan, then in addition to returning to the last completed data point, the system also reduces the positioner speed. No data are lost and no operator intervention is required.

2.4.4 RF Source Enclosure

a. The RF source enclosure is located behind the feed enclosure. This enclosure contains an HP 8340B signal source, HP 8349B microwave amplifier, HP 83554A millimeter-wave source module, Logimetrics traveling wave tube amplifier (TWTA), mixers, and two HP 37204A fiber optic bus extenders.

b. The HP 8340B signal source provides the necessary RF signals from 6 to 18 GHz. Above 18 GHz, the system also uses the HP 83554A (in conjunction with the HP 8340B and HP 8349B) to operate up to 40 GHz. The HP 8349B provides RF amplification to 18 GHz, and the TWTA is used for RF amplification from 18 to 40 GHz.

c. The HP 8340B is commanded by the HP 8510B network analyzer over the HP 8510B system bus using one of the HP 37204A fiber optic bus extenders. The other fiber optic bus extender is connected to the TWTA and is not part of the system bus extender located at the computer.

2.4.5 LO Source Enclosure

The LO source enclosure is located on the positioner tower below the azimuth turntable. This enclosure contains an HP 8341B source, an HP 37204A bus extender, and the LO amplification assembly. The HP 8341B is controlled by the HP 8510B through the HP 8510B system bus. The LO assembly is controlled and monitored by the computer controller via the GPIO lines. The GPIO controls the LO amplifier power supply and selects the proper LO amplifier.

2.4.6 Remote Control of the HP 8510B

The HP 8510B is located in the equipment enclosure 350 feet (in terms of cable length) from the controlling computer. One of the features of the instrumentation control software is a graphical interface specially designed to allow the operator to have manual control of the HP 8510B from the Micro VAX Workstation. The interface is a graphical duplication of the front panel of the HP 8510B. The buttons of the front panel are activated by clicking the mouse cursor over the desired button displayed on the screen. This action has the same effect as an HP 8510B operator pressing buttons on the front panel. Data and messages that appear on the video display of the HP 8510B are routed and displayed on the simulated HP 8510B CRT display on the Micro VAX Workstation.

2.5 REFLECTOR ALIGNMENT

a. The reflector for the Compact Range was designed, fabricated and erected under a subcontract to ESSCO, Concord, MA. (refs 7 and 8, app G). Initial alignment was accomplished using a theodolite and standard surveying techniques. The accuracy of the alignment was then verified by the use of photogrammetry. A summary of these measurements (ref 9, app G) appears in appendix D.

b. The reflector surface was assembled onto the backstructure in a face-up configuration and rough aligned. The reflector was then lifted into its final vertical orientation, and the surface was fine tuned.

c. The results of modeling studies and actual measurements performed by ESSCO are summarized as follows:

(1) The surface change due to backstructure thermal changes between day and night was measured to be 2.5 mils.

(2) The final surface accuracy was measured to be 4.8 mils.

(3) Individual panels were measured to be 1.0 mils.

(4) Modeling estimates for panel thermal deformation is 1.0 mil, panel wind deflection is 1.5 mils, and backstructure wind deflection is 3.3 mils.

Combining all of these errors on a root-sum-square (RSS) basis yields a total reflector accuracy of 6.7 mils RSS.

d. Actual measurements on the central 56-foot diameter section of the reflector yielded a final RMS surface accuracy of 5.26 mils. The RMS surface accuracy of the zone from a diameter of 56 feet to a diameter of 64 feet was 8.03 mils, and the RMS surface accuracy of the zone from a diameter of 64 feet to the tips of the reflector edge serrations at a diameter of 75 feet was 21.87 mils.

e. Preliminary analyses of field probe data collected to date indicate that the current alignment of the reflector has met the design goals. More detailed analyses of the adequacy of the alignment and its effect on quiet-zone quality cannot be performed until many more data points are collected over the entire 50-foot diameter quiet zone using a precision laser-corrected field probe.

2.6 ACCEPTANCE TESTING PERFORMED BY GTRI

Acceptance testing of the Compact Range took place during the first half of 1990. It included testing of the computer system, RF instrumentation, limited quiet zone field probe measurements, standard gain horn antenna pattern measurement validation tests, and load testing with an M1 Abrams tank mounted on the positioner. Antenna pattern tests using standard gain horns were conducted at the same frequencies as the field probe measurements (table V, page 2-34). Absolute gain measurements were not taken. Qualitative comparisons of the patterns agreed well with the manufacturer's published data for typical antennas of this kind. Measured main beam and sidelobe structure were very symmetrical at all test frequencies. Copies of these standard horn antenna patterns appear in appendix C. The acceptance test plan appears in appendix E.

2.7 QUIET ZONE QUALITY

a. On a far-field antenna range, the beamwidth of the illuminating antenna is chosen to give a reasonably constant amplitude variation (low taper) over the antenna under test (AUT), typically less than 0.25 dB. Because of the geometry involved, the phase variation over the AUT will be parabolic. The standard definition of the "far-field distance" for a particular antenna is that distance such that the phase variation is less than 1/16th wavelength (22.50 degrees). Thus the characteristics of an antenna measured on a good far-field range (as defined above) will be close to, but not quite the same as, the characteristics that would be measured on an ideal range, if such a thing existed. An antenna range with these characteristics is suitable for measuring an AUT that does not have extremely low sidelobes (no better than -30 dB), since the presence of the phase taper will most directly corrupt the measured sidelobe level. The field variations can be described analytically so that the effect on measured patterns can be estimated easily.

b. Ground (and other) reflections will create perturbations in the incident field of a far-field range and also corrupt the measurements, but if the range geometry is such that refractions are not a problem (as is usually the case), the "nearly uniform" field described above can be easily achieved using standard hardware. Thus, most far-field antenna ranges are seldom probed unless there is reason to believe that reflections are a problem, or if a very low sidelobe antenna is to be measured.

c. The incident field that can be achieved with a compact range utilizing a prime-focus paraboloid has inherently different characteristics from that of the far-field range described above. The area where this field is designed to exist is commonly called the "quiet zone" of the compact range. Because of the nature of the paraboloidal reflector, the phase in the quiet zone can be made relatively uniform, but with cyclic variations (ripples due to the effect of reflections and diffraction from the edge of the paraboloid and other sources). In the case of the USAEPG Compact Range, the ground between the feed and the reflector is the major source of reflections.

d. Typically, the amplitude of the quiet zone field will have a greater taper than that of the far-field range because of the combined effects of the feed pattern itself and the "space taper" caused by the paraboloid. There will also be ripples on top of the amplitude taper due to the effects of reflections and edge diffraction just as is the case with the phase. Thus the field distribution of a compact range is inherently more complex than that of a far-field range and requires more careful examination. The smaller the ripples can be made, the better will be the quiet zone.

2.7.1 Compact Range Performance Prediction

a. The work in this area was aimed toward establishment of compact range computer models which would represent the key electromagnetic contributions to the quiet-zone fields. These include illumination of the reflector by the feed, collimation of this energy by the reflector, scattering of feed energy from the reflector and the ground via the diffraction fence, direct back radiation from the feed to the quiet zone, etc. The models also compute electromagnetic effects due to the panel gaps, the reflector edge serrations, and the fence edge.

b. Some sub-elements of this model were completed early in the program and were used to provide preliminary computations of the effect of the panel gaps and to determine the optimum reflector focal length and edge serration (petal) design for input to the reflector vendor as described above. The construction of the total model was successfully completed in December 1987 and the model was exercised extensively through January 1988 to determine the final configuration for the diffraction fence design and to evaluate the predicted performance of the compact range (i.e., quiet-zone quality).

c. Table IV shows the predicted worst-case performance of the 50-foot quiet zone field of the total compact range system over the frequency range of 6 GHz to 40 GHz.

TABLE IV. QUALITY PREDICTION FOR 50-FOOT DIAMETER QUIET ZONE
(Worst-case results over a range of 6 to 40 GHz)

Compact Range Parameter	Amplitude Taper	Amplitude Ripple
Feed horn/focal length	0.5 dB	-
Reflector edge scattering	-	± 0.15 dB
Reflector surface smoothness and panel offset (high F)	-	± 0.50 dB
Reflector panel gaps (low F)	-	± 0.18 dB
Back radiation from feed	-	± 0.20 dB
Ground reflection	-	± 0.50 dB
Root-sum-squared	0.5 dB	± 0.76 dB

2.7.2 Field Probing Issues

a. The primary purpose of probing any antenna measurement range is to determine the characteristics (spatial distribution of amplitude and phase) of the field incident on the AUT. These characteristics are indicative of the "quality" of the range and the accuracy of antenna measurements that are performed on the range. The ideal antenna measurement range will have a field distribution that has uniform (constant) amplitude and phase over the entire extent of the AUT.

b. The quiet zone field must be probed not only as part of the initial establishment and alignment of the range geometry, but also to determine the field structure so that the effect that any perturbations will have on measurement of the AUT can be estimated. Ideally, the entire quiet zone would be probed, with field samples taken at no greater spacing than a half wavelength. As a practical matter, this would not be done unless the range were to be used for extremely accurate measurements of very low sidelobe antennas because of the time, manpower, and cost involved. It is usually considered sufficient to perform a limited set of probe cuts over the quiet-zone area. The average level of amplitude and phase variations that are measured in the quiet zone can be used to estimate how accurately the sidelobes, gain, and beamwidth of the AUT can be determined. Spatial transforms of the measured data can also be used to determine the physical location of extraneous scattering so that the cause can be eliminated.

c. The ultimate purpose of the field probe is to provide data which, to some extent, characterizes the quality of the quiet zone, thereby providing information that may be used to evaluate the potential performance of the compact range in measuring antenna patterns. Perhaps more importantly, gathering field probe data periodically can provide verification that range performance has not deteriorated over a period of time, or can provide diagnostic information if indications are that

the range is not performing properly. Because the quiet zone field is dependent in a very complex way on the geometry of the range, on extraneous reflections, and on edge diffraction, a change in any of these could cause perturbations to the field. Therefore, it would be important to re-probe the range if there were an indication that any of these items had changed. Such changes could include physical damage to reflector panels or the edge treatment, movement of or damage to the ground reflection fence, deterioration of absorber panels due to environmental effects, and improper placement of the feed when changing the frequency band. If questionable and/or unexplained results are obtained during the measurement of an AUT, the only way to be sure that the range is not at fault is to re-probe the quiet zone. Clearly, a trade-off must be made between the desired level of characterization and the time and expense of not only gathering, but also analyzing, the resulting data.

d. During the installation of the Compact Range at Fort Huachuca, field probe data were taken. Representative plots of the data appear in appendix B. There are five frequency bands covering the specified frequency range of 6.0 to 40 GHz (6 to 8, 8 to 12.4, 12.4 to 18, 18 to 26.5, and 26.5 to 40 GHz). Because of difficulties in using the field probe, the probe was mounted at the center of the turntable. This permitted the central 13-foot center section to be probed. The field was probed at frequencies over the 6- to 40-GHz range to provide a reasonable indication of the performance of the compact range. This selection of frequencies provided probe data at the low, mid, and high frequencies of each band. Duplicate data were taken at each frequency at which the bands intersect because there are differences in the performance of the individual feed horns used for each band. Cuts were made with the probe positioned vertical and horizontal. The specific frequencies at which data were taken are as shown in table V.

TABLE V. FIELD PROBE MEASUREMENT FREQUENCIES

Portion of Band	C Band 6-8 GHz	X Band 8-12.4 GHz	Ku Band 12.4-18 GHz	K Band 18-26.5 GHz	Ka Band 26.5-40 GHz
Low	6.0 GHz	8.0 GHz	12.4 GHz	18.0 GHz	26.5 GHz
Mid	7.0 GHz	10.0 GHz	15.0 GHz	22.0 GHz	35.0 GHz
High	8.0 GHz	12.4 GHz	18.0 GHz	26.5 GHz	40.0 GHz

e. A summary of the peak-to-peak amplitude and phase variation data appears in tables VI and VII. Several reflector panels have been readjusted since this data was taken. The success of this adjustment will not be known until the field is re-probed.

TABLE VI. FIELD PROBE DATA, AMPLITUDE RIPPLE
(dB, peak-to-peak)

θ	polar-ization	C Band			X Band			Ku Band			K Band			Ka Band			
		6	7	8	8	10	12.4	12.4	15	18	18	22	26.5	26.5	30	35	40
0	Vert	0.9	1.7	1.4	1.5	1.5	2.4	1.7	1.1	0.5	2.6	3.5	3.2	2.8	2.6	2.7	3.9
0	Horiz	1.5	1.7	1.4	1.4	1.8	1.9	4.5	2.4	3.5	2.7	2.8	2.7	3.2	3.0	3.0	3.9
90	Vert	1.6	1.9	2.1	2.6	1.7	1.5	7.8	2.9	4.5	2.4	2.3	2.9	2.9	2.8	3.7	4.2
90	Horiz	1.9	1.9	2.2	2.2	2.3	1.9	4.9	2.7	1.8	3.0	2.2	2.1	2.0	2.8	2.9	3.4

TABLE VII. FIELD PROBE DATA, PHASE VARIATION
(degrees, peak-to-peak)

θ	polar-ization	C Band			X Band			Ku Band			K Band			Ka Band			
		6	7	8	8	10	12.4	12.4	15	18	18	22	26.5	26.5	30	35	40
0	Vert	21	25	33	28	37	43	47	60	70	74	79	94	74	95	101	116
0	Horiz	21	26	30	39	46	56	41	67	74	77	89	100	78	95	103	112
90	Vert	16	19	25	22	18	19	72	35	36	61	28	46	30	31	44	42
90	Horiz	18	25	27	15	25	28	42	87	70	62	22	44	31	36	49	50

2.8 TEST VEHICLE MOUNTING

The Compact Range positioner turntable has been designed to allow interfacing a variety of test vehicles. For very heavy vehicles particular attention must be taken to design the interface mounts to minimize the moments of inertia about the center of rotation. Figure 18, page 2-25 shows the many mounting holes that are available on the positioner turntable. This allows for a high degree of flexibility in positioning the test vehicle over the turntable to minimize inertial loading.

2.8.1 M1 Abrams Tank

a. Mounts have been designed to interface an M1 Abrams tank to the Compact Range pedestal turntable. The tank engine was left installed. All fluids were drained and the batteries were removed. In order to accommodate the mounting plates, three road wheels, idler arms and their torsion bars were removed from each side. The tracks were put back on after removal of the road wheels.

The final weight of the tank in its mounting configuration was measured by the lifting crane to be about 63 tons. The mounting plates were designed to allow placement of the tank's center of gravity as close as possible to the turntable center of rotation whether or not the engine power pack was installed. The photograph at the beginning of this report shows the M1 tank as mounted on the positioner turntable during acceptance testing.

b. Load tests were performed as part of the acceptance testing. It was necessary to modify the existing positioner control software to limit the maximum turntable acceleration/deceleration with such a massive test load on the turntable platform. A low-pass filter was also installed in the manual positioning control circuitry to limit the peak acceleration and deceleration of the test load while under manual control.

2.8.2 OV-1 Mohawk Aircraft

a. A mounting bracket has been designed to interface an OV-1 Mohawk aircraft to the Compact Range positioner turntable. This aircraft is one owned by the USAEPG Antenna Test Facility. The Mohawk's engines and most of the cockpit instrumentation have been removed. The mounting bracket interfaces to the aircraft at the wing attachment points on each side. Th mount was designed to allow placement of the aircraft on the turntable in both normal and inverted flight aspects. This permits measurement of antenna pattern data over both lower and upper hemispheres of coverage.

b. Figures 20 and 21 show the OV-1 Mohawk aircraft as mounted in its normal and inverted flight aspects, respectively. The mounting for the normal flight aspect was completed and tested while this report was being prepared. It was necessary to adjust the gain of the servo loop in order to eliminate low-frequency oscillations of the test item. These oscillations were most likely due to the higher azimuth moment of inertia of the airplane as compared to the M1 Abrams tank.

c. Inverted mounting of the aircraft will be completed during Phase II of this methodology investigation.

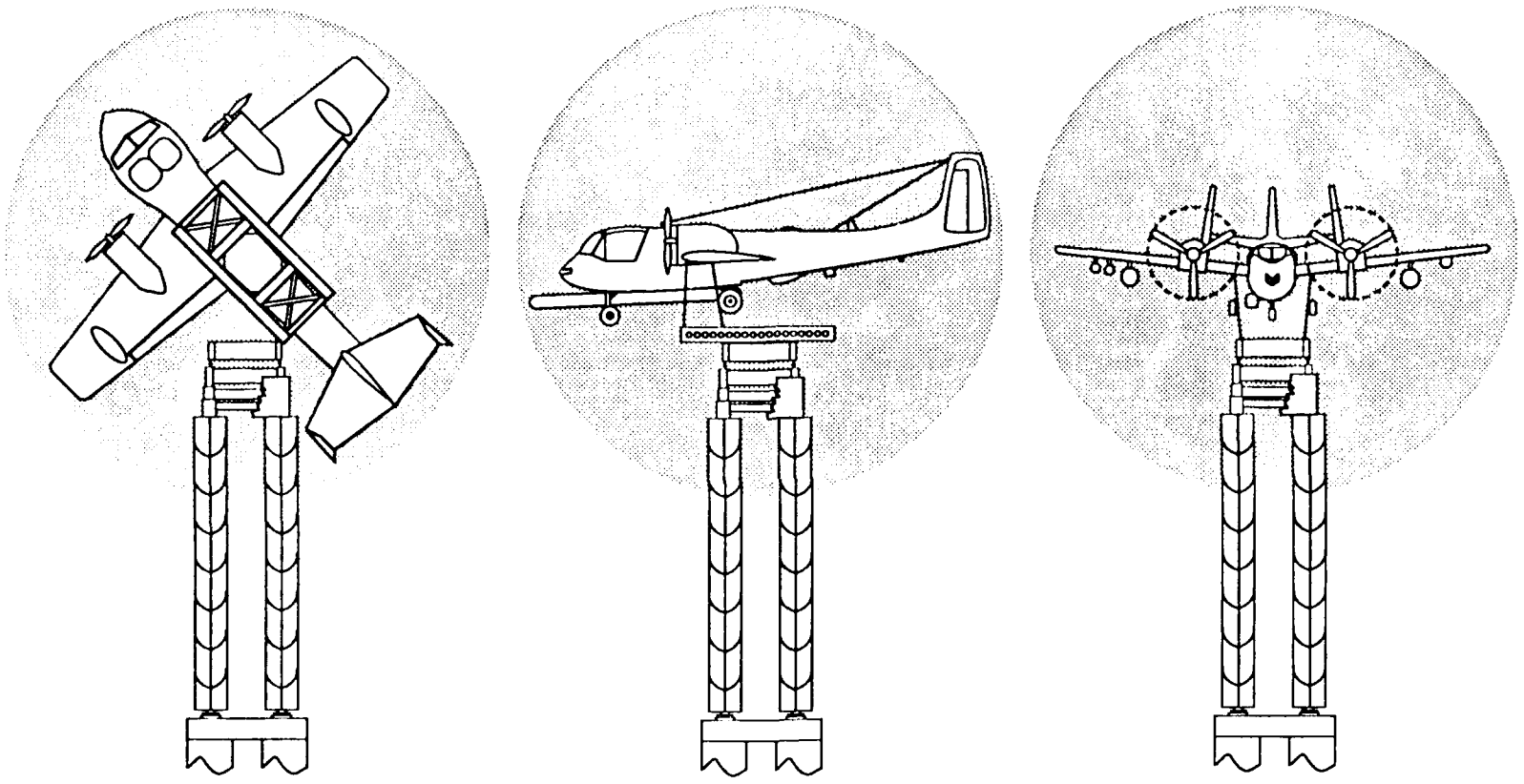

Figure 20. OV-1 Mohawk aircraft mounting (upper hemisphere coverage).

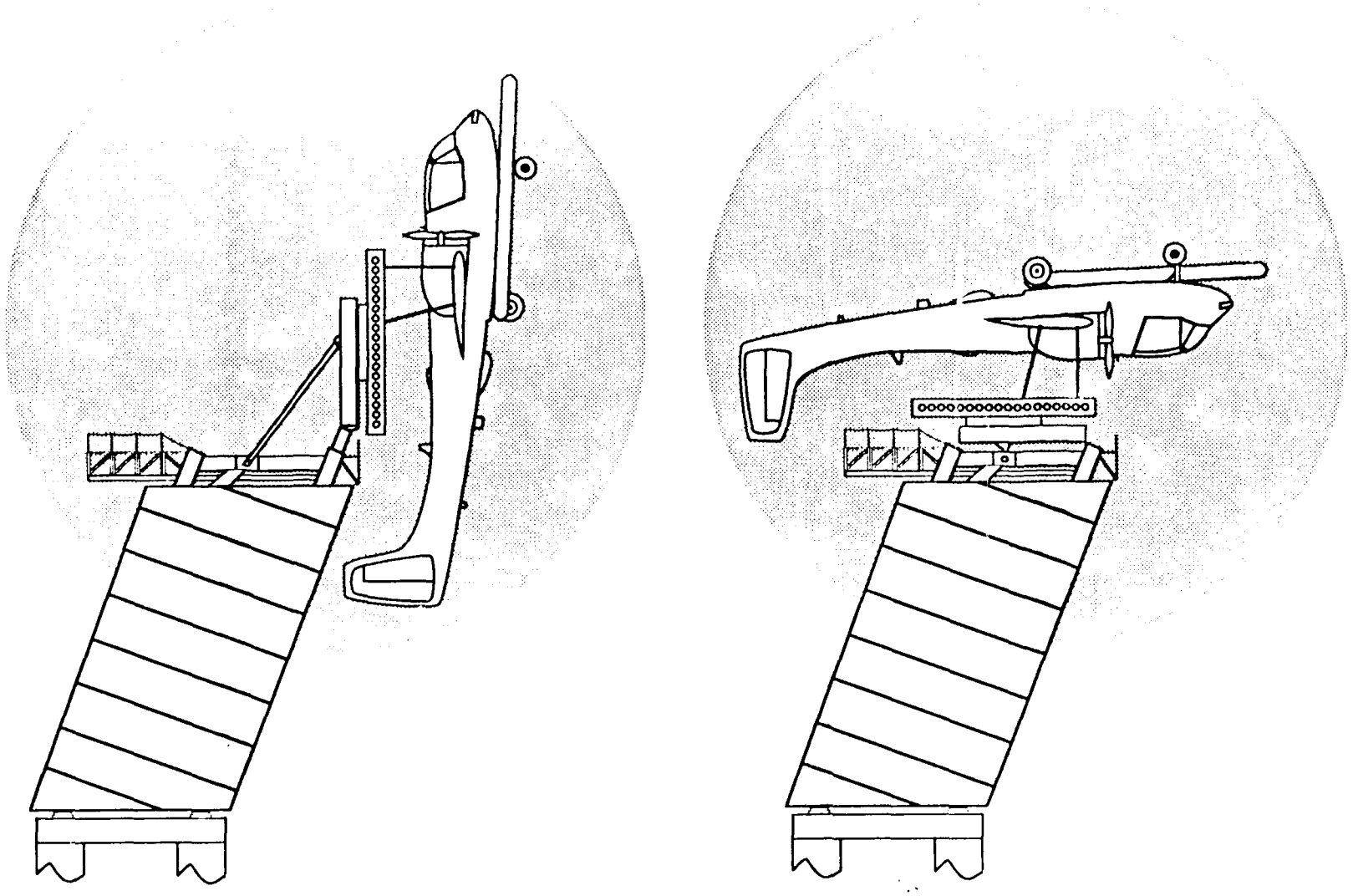

Figure 21. OV-1 Mohawk aircraft mounting (lower hemisphere coverage).

2.9 RANGE RECEIVER

2.9.1 Curr nt Implementation of the HP 8510B

a The HP 8510B range receiver is currently operated in CW dual-source mode. The HP 8510B provides frequency control of the RF source and LO signal generators. The appropriate frequency definitions and mixer harmonic equations are loaded into the HP 8510B by the system software. The resulting 20-MHz intermediate frequency (IF) signals from the RF reference mixer and from the LO mixer are applied to the HP 8510B IF/detector section for the second-frequency conversion to 100 kHz, detection, post-processing, and display on the HP 8510B monitor.

b. Another feature of the instrumentation control software for the HP 8510B is a graphical interface designed to allow the operator to remotely control most front-panel operations from the Micro VAX Work-station in the control van. This feature is discussed in section 2.4.6.

c. Problems have been identified in the current implementation of the fast-CW mode of the HP 8510B. Hewlett Packard (the manufacturer) is aware of these deficiencies and plans to correct them in the future by revising the internal firmware. The problem is one of controlling how the Compact Range times its data output requests from the HP 8510B in the fast-CW mode. The HP 8510B often locks up and becomes unresponsive if the timing is not exactly right. It has been difficult to work around this problem by patching the Compact Range software. An easier approach would be to upgrade the HP 8510B to an 8510C. At a cost of about $12,000 this upgrade would eliminate the bugs seen in the 8510B.

2.9.2 Time-Domain Mode for Diagnostics and Range Gating

a. The time domain mode of the HP 8510B is a very useful diagnostic tool that can help in the isolation of equipment problems and location of clutter sources and target anomalies.

b. Figure 22 is a time-domain plot of the Compact Range as configured for X-band operation (12.4 to 18 GHz). This plot was taken prior to range calibration. Undesired responses can be seen at 0 nanosecond and at +40 nanoseconds. From this data it was determined that the first response at 10 dB down and 0 nanoseconds was largely due to the lack of calibration of the range receiver and this response, internal to the HP 8510B, would most likely be removed once the receiver was properly calibrated. The second response at 26 dB down and +40 nanoseconds was determined to be a result of direct coupling between the feed horn and the antenna under test. This mutual coupling response is a good example of the kind of multipath responses that are dictated by the geometry of the range, but could be removed by employing range gating techniques.

c. Time-domain gating can also be used to isolate desired target responses from undesirable clutter returns, improving the quality and accuracy of the measured data. From figure 22 it can be seen that there are several clutter sources around the desired response at about +300 nanoseconds. This region has been expanded in figure 23. The combined effects of the clutter sources can be seen to contribute undesired responses in the order of 20 to 13 dB below the desired response. Figure 24 is an example of how these unwanted responses can be removed by utilizing a time gate of 5.0 nanoseconds about the desired response.

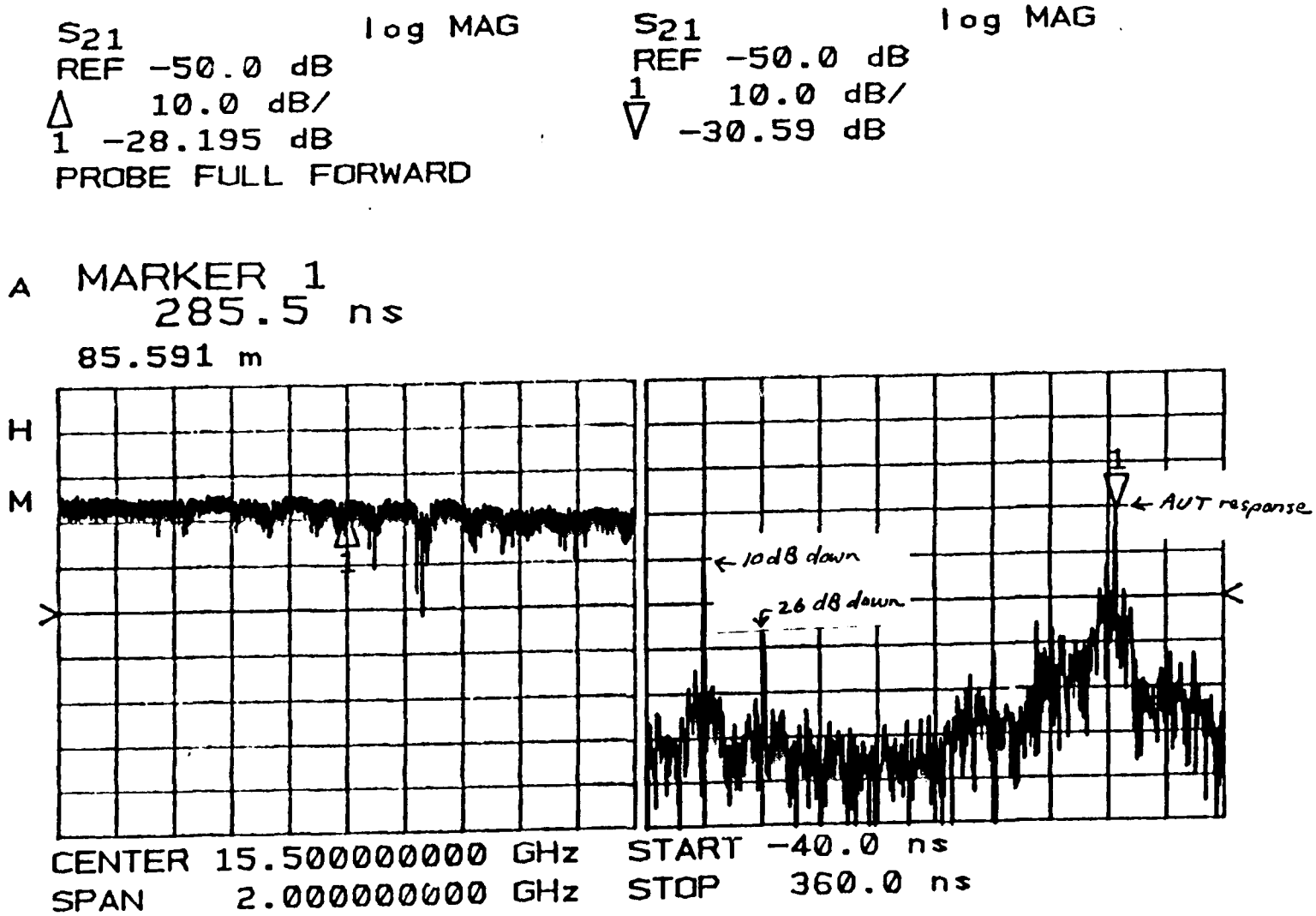

Figure 22. Range receiver time domain plot, feed-to-AUT coupling.

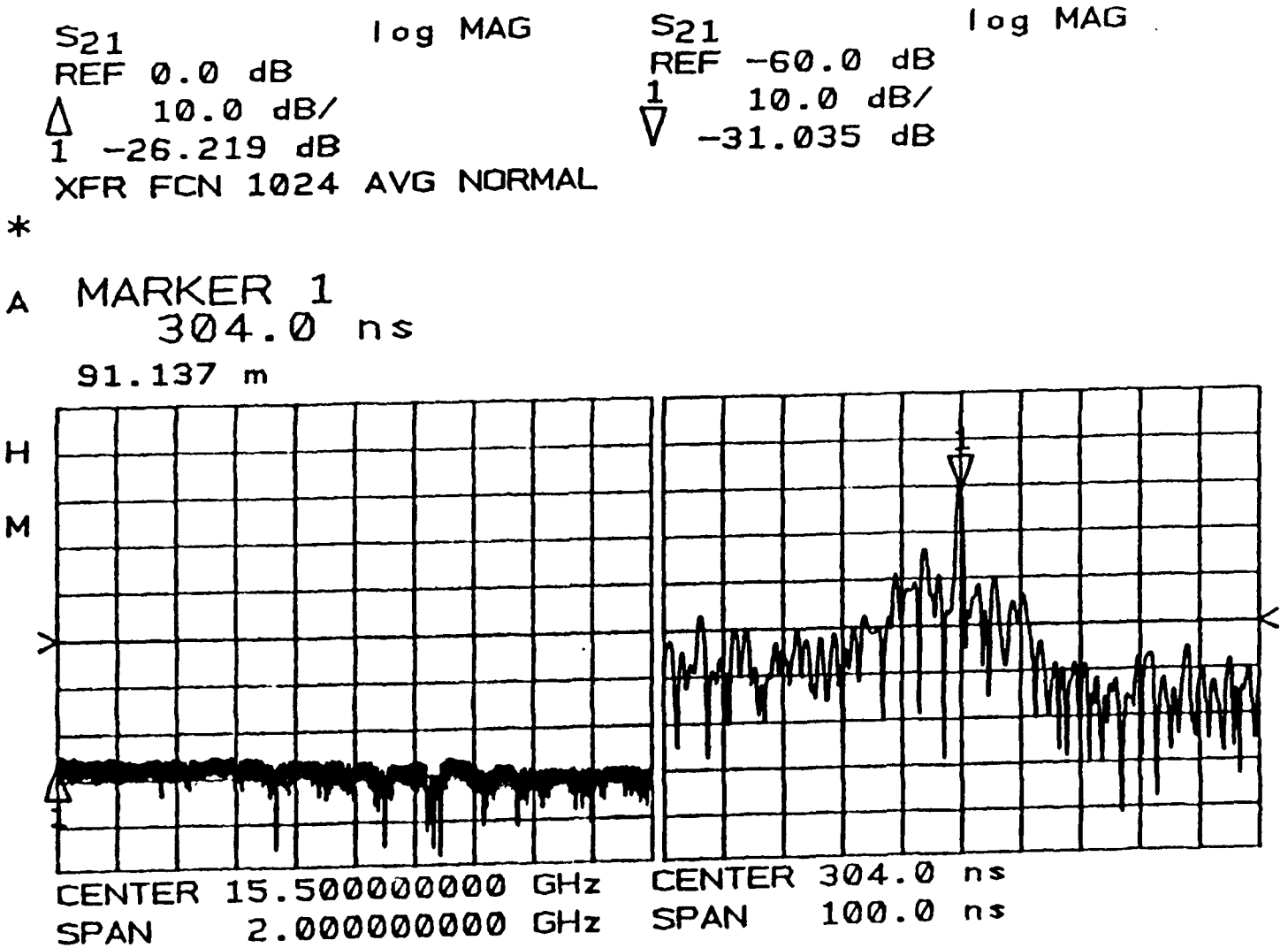

Figure 23. Range receiver time domain plot, non-gated response.

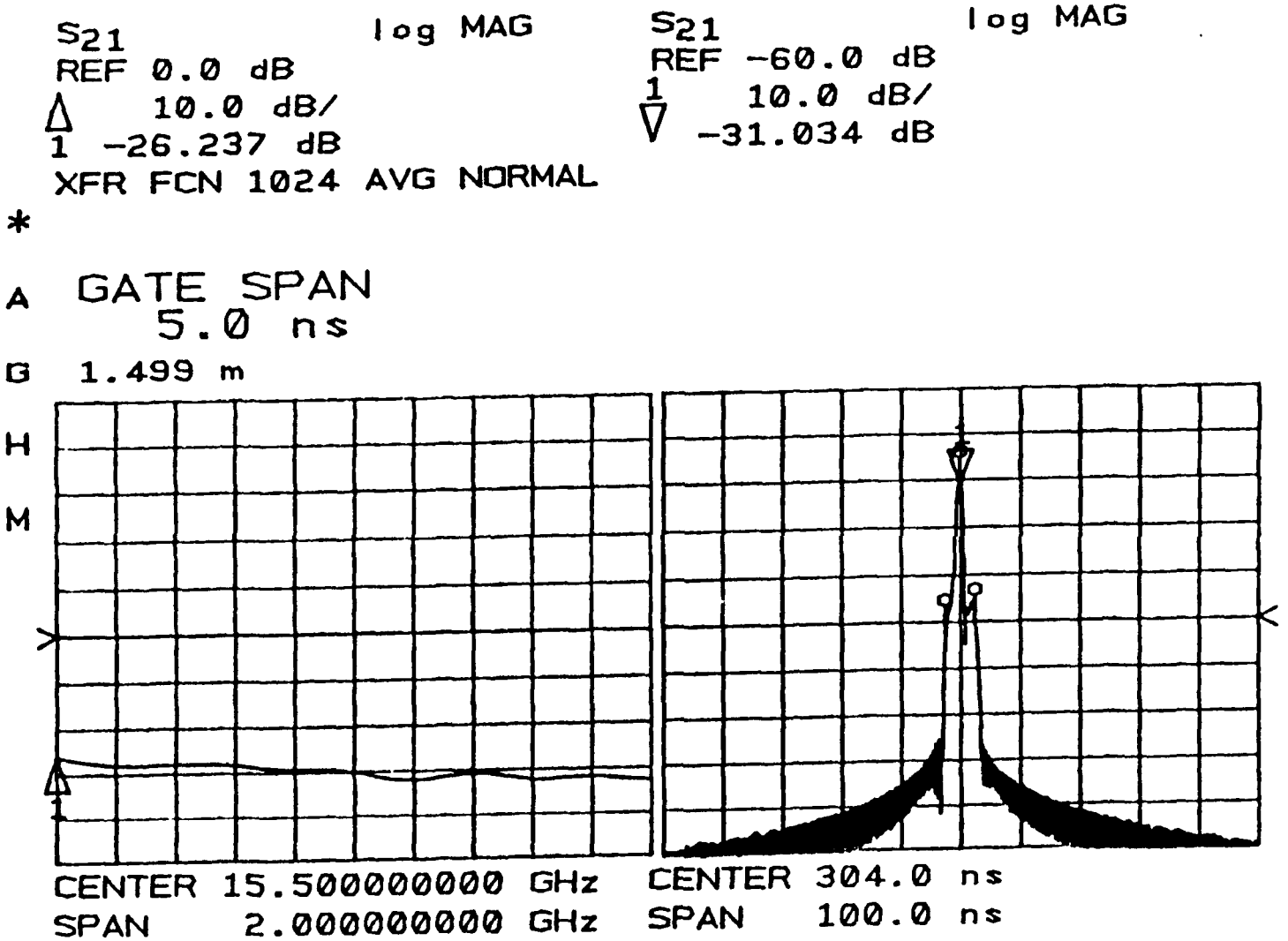

Figure 24. Range receiver time domain plot, gated response.

2.10 TEST AND MEASUREMENT SUPPORT INSTRUMENTATION

a. As part of this study, some equipment has been purchased to augment the test and support measurement capabilities of current range equipment. The range instrumentation provided with the GTRI system did not include any spares and this was identified as an area that needed to be addressed. In addition, the current test instrumentation available to range personnel was lacking in its ability to perform RF measurements above 22 GHz.

b. The Compact Range RF system uses a series of three different signal mixers to provide frequency coverage from 6 to 18 GHz, 18 to 26.5 GHz, and 26.5 to 40 GHz. Two of each kind of mixer are used in the configured system to downconvert the reference and signal channels to the 20-MHz IF inputs of the HP 8510 range receiver. Two of the 6- to 18-GHz mixers were obtained as system spares. Three of the two high band mixers were obtained to be utilized as both system spares and to expand RF measurement capabilities beyond the previous 22-GHz upper frequency limit. Precision attenuators and test cables capable of operation to 50 GHz were also purchased.

c. The fiber optic instrumentation bus extenders allow the computer system to communicate with the HP 8510 range receiver, RF source, and local oscillator source. These extenders represent possible single points of failure for the system. Several spares were purchased to expedite field replacement and to minimize down time in the event these devices fail.

d. Precision torque wrenches were purchased to enable all RF connections to be tightened according to the manufacturers specifications. This is extremely important with millimeter frequency connectors as they are very susceptible to damage if tightening specifications and good connector mating procedures are not followed.

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SECTION 3. APPENDICES

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APPENDIX A. METHODOLOGY INVESTIGATION PROPOSAL AND DIRECTIVE

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December 1988

METHODOLOGY INVESTIGATION PROPOSAL

1. TITLE. Compact Antenna Range Test Applications

2. INSTALLATION OR FIELD OPERATING ACTIVITY. U.S. Army Electronic Proving Ground, Fort Huachuca, Arizona 85613-7110.

3. PRINCIPAL INVESTIGATOR. Ms. Beverly Hawks, Surveillance and Range Division, STEEP-ET-U, AUTOVON 879-6581, steepetu@epgl-hua.arpa.

4. BACKGROUND. USAEPG is obtaining a very modern and accurate compact range facility which can provide a far-field RF condition in a short distance. The compact antenna range will provide a unique capability to irradiate large target systems with a highly controlled and precisely oriented EM field. A significant potential application of this capability is the measurement of "upset effects" produced by EM environments that couple directly into the components and circuits of electronic subsystems.

5. PROBLEM. There are other measurements besides antenna patterns for which the compact range is suitable. The cost of making these measurements could be reduced by integrated or combined testing. This process could replace the current procedure of test item measurement at different facilities.

6. OBJECTIVE. To determine how the new compact antenna range at USAEPG can be adapted to other measurements such as target return signals and equipment responses to specialized signal environments.

7. MISSION AREA SUPPORTED. COS

8. PROCEDURES.

Determine technology/equipment needed for target return signal measurement and other specialized signal environment measurements; i.e., electronic equipment, antenna/feed horn, and pylon/pedestal.

Provide an approach to technology development.

Provide an approach to equipment interface.

Provide report with suggested equipment list and methodology.

9. JUSTIFICATION/IMPACT. Data which may be possible to collect at a reduced cost are:

a. Target return measurements.

b. Special specular reflection measurements.

c. Specialized signal environment measurements.

10. DOLLAR SAVINGS. N/A.

Compact Antenna Range Test Applications (Cont)

11. RESOURCES.

a. Financial.

	Dollars (Thousands) FY90		Dollars (Thousands) FY91	
	In-House	Out-of-House	In-House	Out-of-House
Personnel Compensation	26.5	--	30.0	--
Travel	7.0	--	5.0	--
Contractual Support	--	10.0	--	85.0
Consultants & Other Svcs	--	56.5	--	20.0
Materials and Supplies	--	--	--	--
Equipment	--	--	--	--
General & Admin Costs	--	--	--	--
Subtotals	33.5	66.5	35.0	105.0
FY Totals	100.0		145.0	

b. Explanation of Cost Categories.

(1) Personnel Compensation. GS-13 855, Electronic Engineer

(2) Travel.

(a) To organizations presently using compact ranges.

(b) To organizations making target return measurements.

(3) Contractual Support. Special computational analyses.

(4) Consultants and Other Services. Consultation to resolve controversial technical areas.

c. Obligation Plan (FY90).

FQ	1	2	3	4	Total
Obligation Rate (Thousands)	10.0	30.0	30.0	30.0	100.0

d. Manhours Required.

In-House: 900

Contract: 1000

Compact Antenna Range Test Applications (Cont)

12. ASSOCIATION WITH TOP PROGRAM. New TOPs will be prepared when the test applications and test methods development effort is completed.

FOR THE COMMANDER:

ROBERT E. REINER
Chief, Modernization and Test
Technology Office

STEEP-RM-F (70-10p) 6 Oct 89

MEMORANDUM FOR C, S&R Div (ATTN: Mr. Davis, x8-6581)

SUBJECT: Internal Directive, #FY90-008, FY90 RDTE MIP Grant, Compact Antenna Range Test Applications I, TECOM Project No. 7-CO-R90-EP0-006

1. Ref Test Officer's Handbook, Jul 87.

2. You have been assigned as the test officer for subject project. Enclosure 2 (STEEP-RM-F Form 1) contains suspense dates and reporting schedules for this project. You must review the reporting schedules and determine:

a. If the schedules can be met, notify me (TRMS Monitor, Wanda L. Casaus, x8-7683) NLT 25 Oct 89 for entry into the TRMS.

b. If rescheduling is necessary because of lack of resources a first endorsement must be prepared per Tab 1 of ref and arrive at TECOM by the above suspense date.

3. Supporting estimates are to be provided to you IAW the test schedule (STEEP-RM-F Form 1) dates. You will submit the cost and manhour estimate(s) (EEP Form 1301) through me to the Bud & Prog Div. The Bud & Prog Div will issue and expenditure order (EO)(XO) number and necessary cost centers will be opened upon receipt of project funds (See Tab 3 of ref).

4. Prior to start of testing/support you must coordinate with the following:

a. Environmental Quality Coordinator (EQC), x8-6182.

b. Foreign Intelligence Ofc (FIO), x8-6961. (See Tab 5 of above ref)

c. Intelligence & Security Div, x8-6077. (See Tab 6 of above ref)

d. MANPRINT/RAM Div, x8-2929, if Human Factors Engineering (HFE) and/or Reliability, Availability, & Maintainability (RAM) services are required.

e. M&TT Ofc, x8-7602, for Test Operations Procedures (TOPS) on the formulation of test plans. (See Tab 15 of above ref)

f. E3 Div, Mr. Weeks, x3-5819, if TEMPEST Testing is anticipated. (See Tab 31 of above ref)

g. PAO, x8-6211 if photographic coverage is required for test items, final reports, in-house briefings, etc.

h. TRMS Monitor, x8-7683, to obtain one or more project notebooks. (See Tab 4 of above ref)

i. Safety Office, x8-6181. (See Tab 23 of above ref)

STEEP-RM-F (70-10p)
SUBJECT: Internal Directive, #FY90-008, FY90 RDTE MIP Grant, Compact Antenna Range Test Applications I, TECOM Project No. 7-CO-R90-EP0-006

5. A project description will be sent to you via Profs notes. Request this note, subj: PD, Compact Antenna Range, 7COR90EP0006, be completed and the note resent to TRMS2 NLT 26 Oct 89. In order to type on the note you must press PF7 (Resend) and then type the note. Press PF7 (Send) again and this will send the note to TRMS2. I will then forward this information to the Test Directors, Technical Director, and the Commander, USAEPG.

6. Wanda L. Casaus, TRMS Monitor, STEEP-RM-F, x8-7683, is the POC for this office.

FOR THE COMMANDER:

Patricia Slaybaugh.

2 Encl

PATRICIA A. SLAYBAUGH
Actg C, Force Management Division

CF:
Tech Director
PAO
USMC LNO
EPG Read File
Fac Mgr
C, IS Div
TRMS
Safety Engr
C, Bud & Prog Div
Cdr, Bn
D, ETT
C, M&TT Ofc
C, Tech Pubs Div
C, S&I Div
C, EWI Div
D, C3 Test
C, E3 Div
C, Comm Div
C, MR Div
C, C2 Div
C, FIC

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APPENDIX B. FIELD PROBE DATA

C Band, 6 to 8 GHz ..... B- 3
X Band, 8 to 12.4 GHz B-19
Ku Band, 12.4 to 18 GHz B-39
K Band, 18 to 26.5 GHz B-52
Ka Band, 26.5 to 40 GHz B-82

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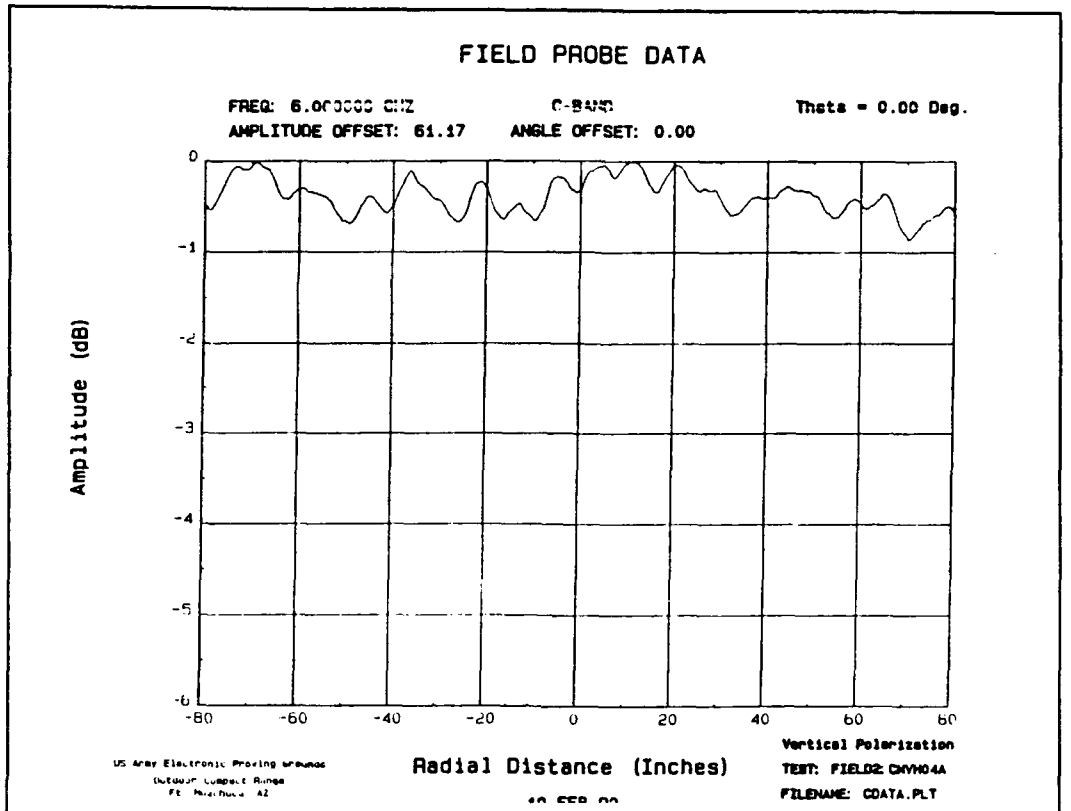
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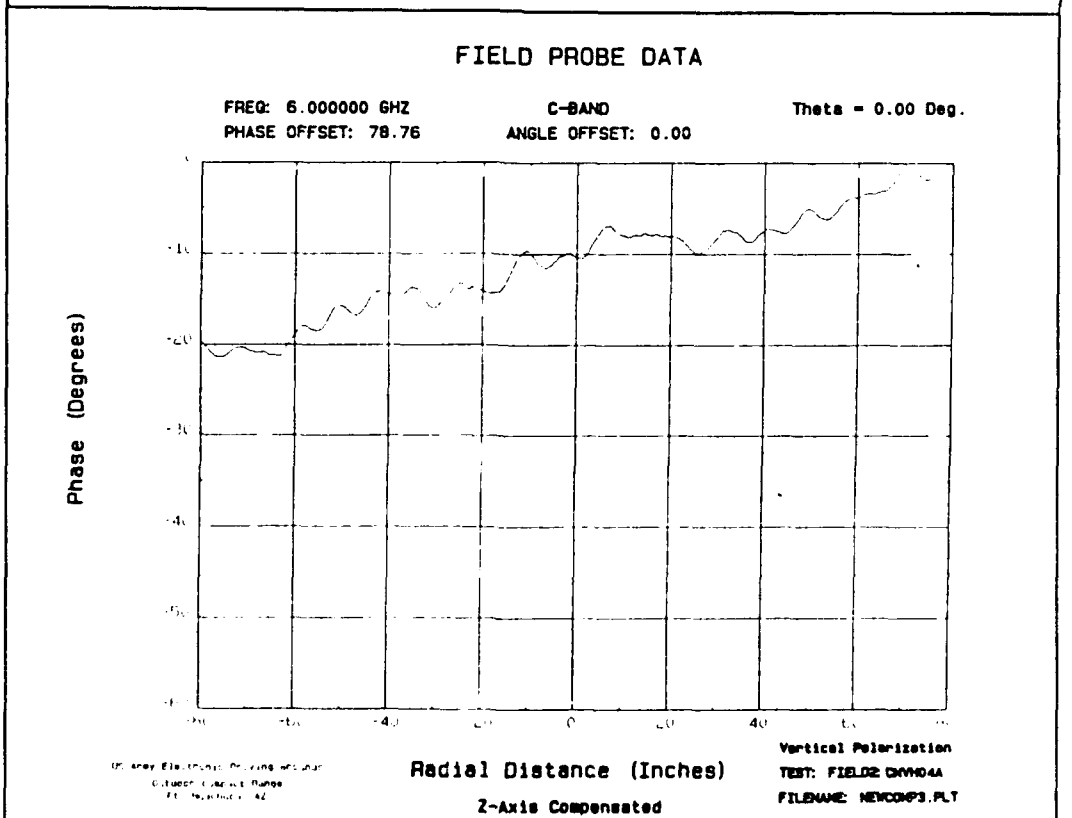
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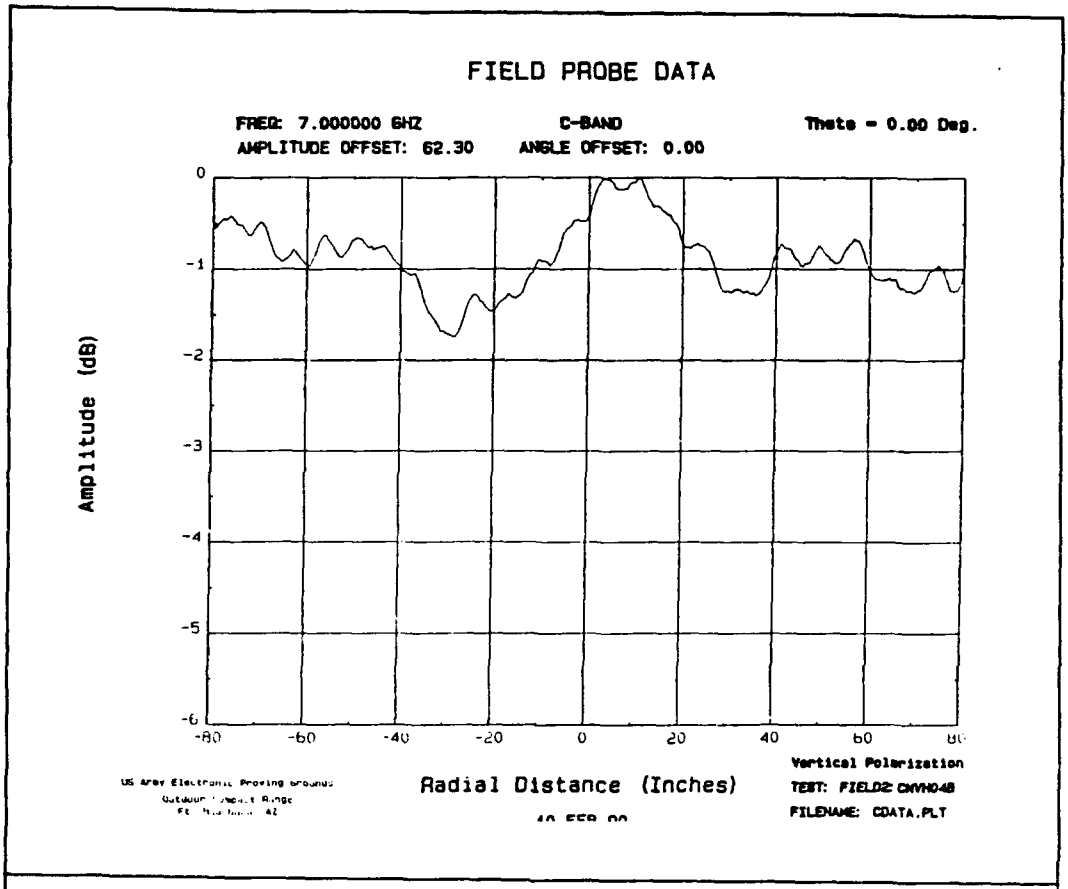
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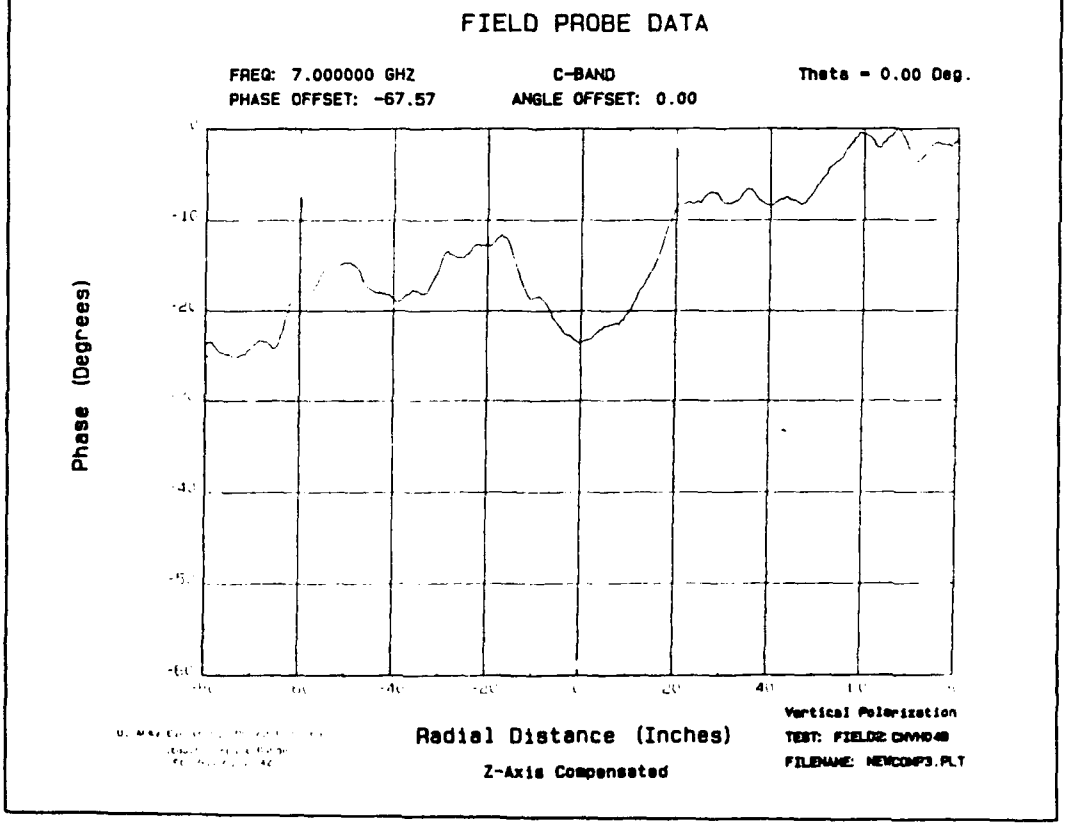
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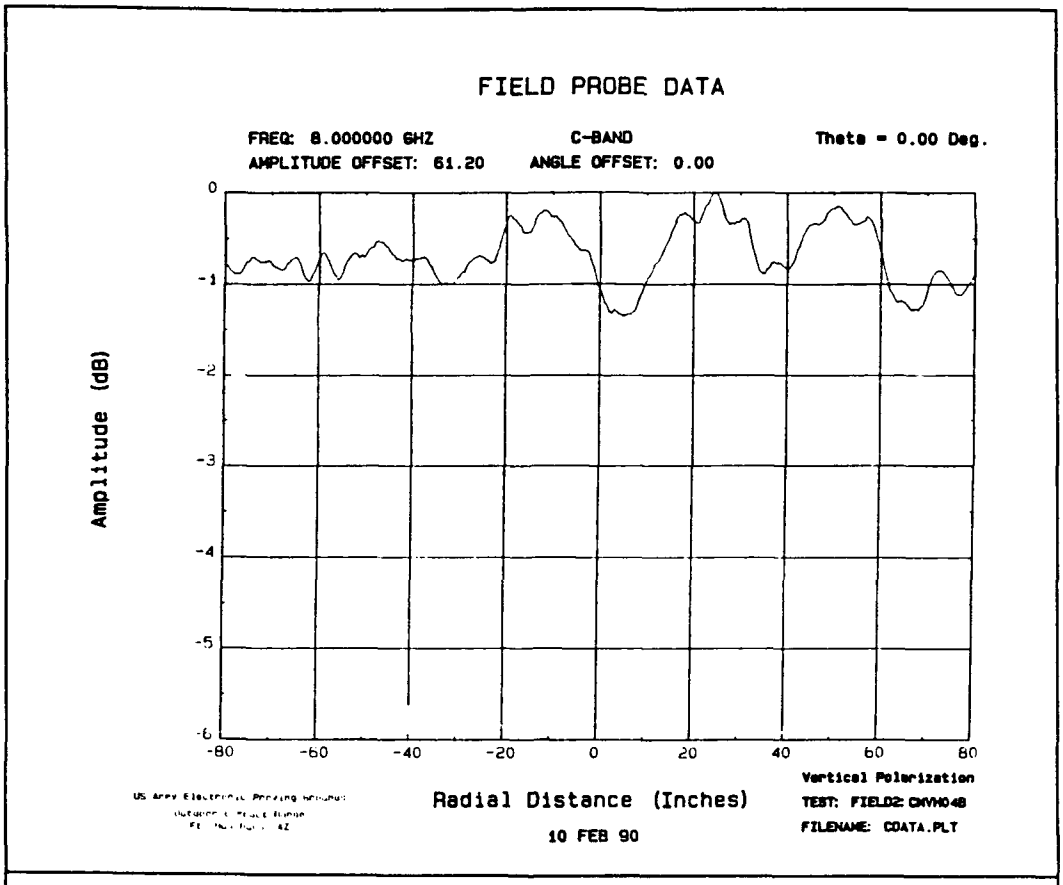
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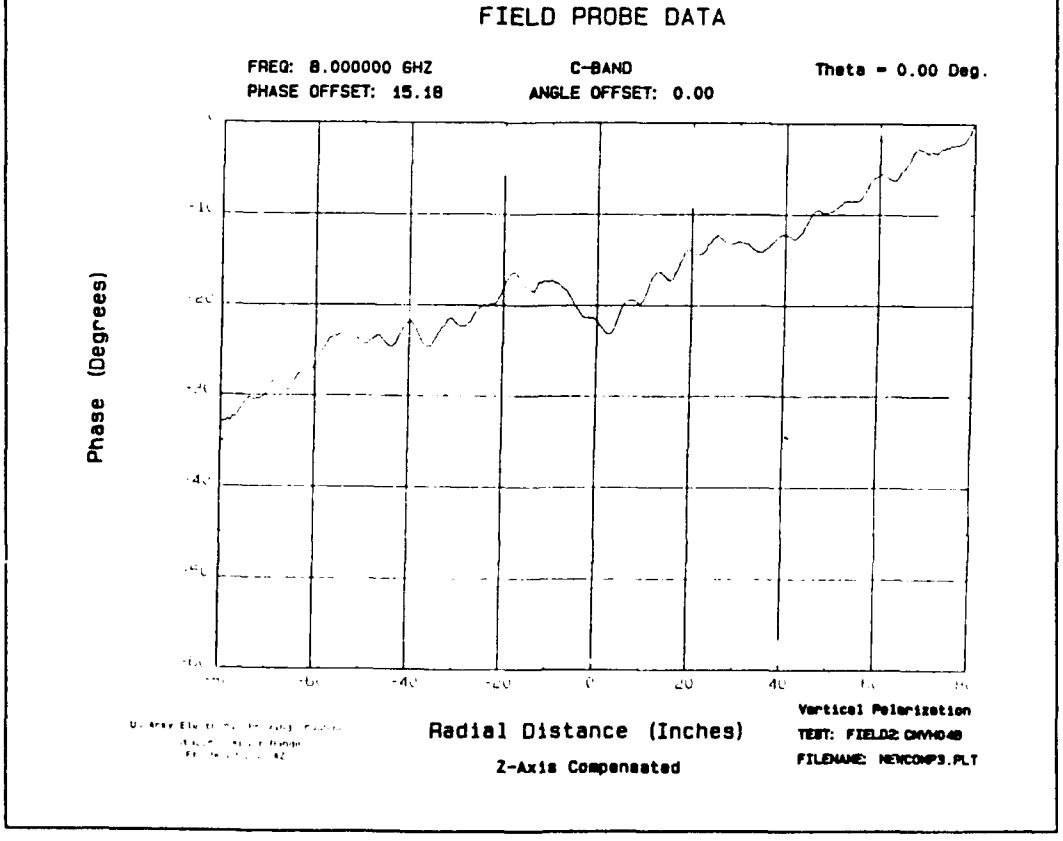
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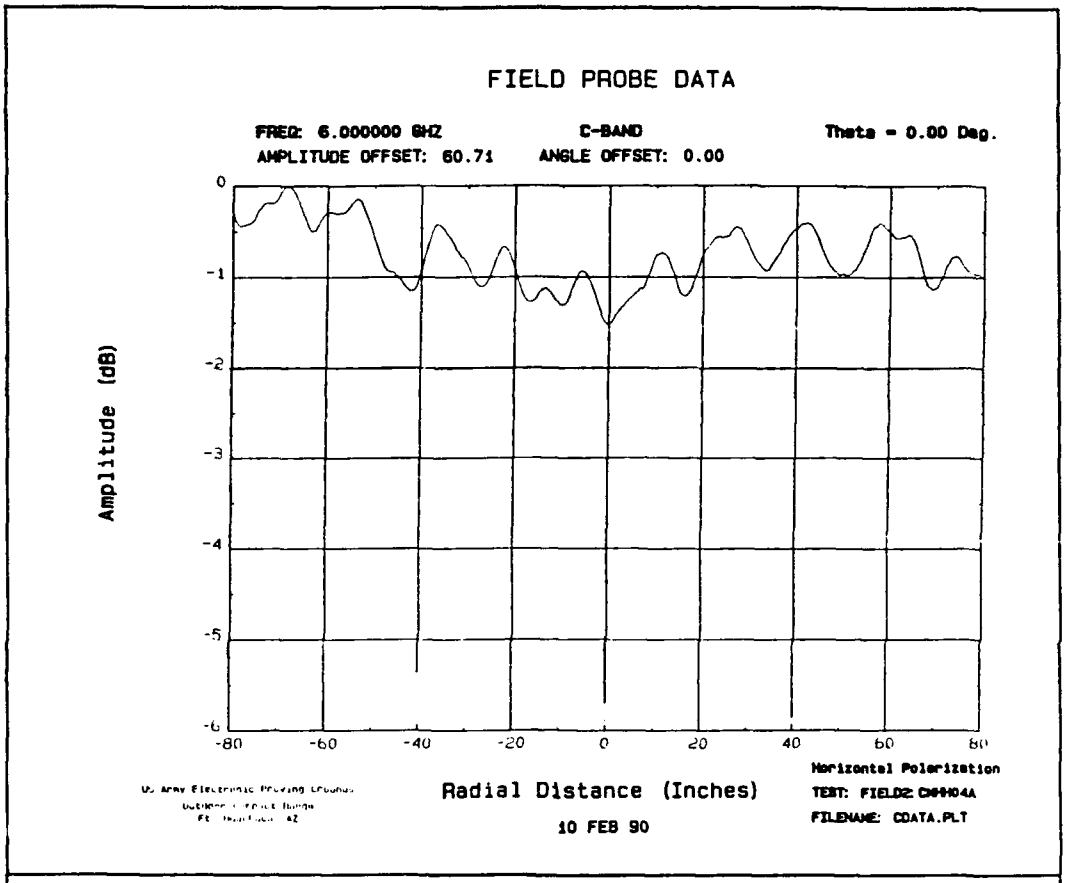
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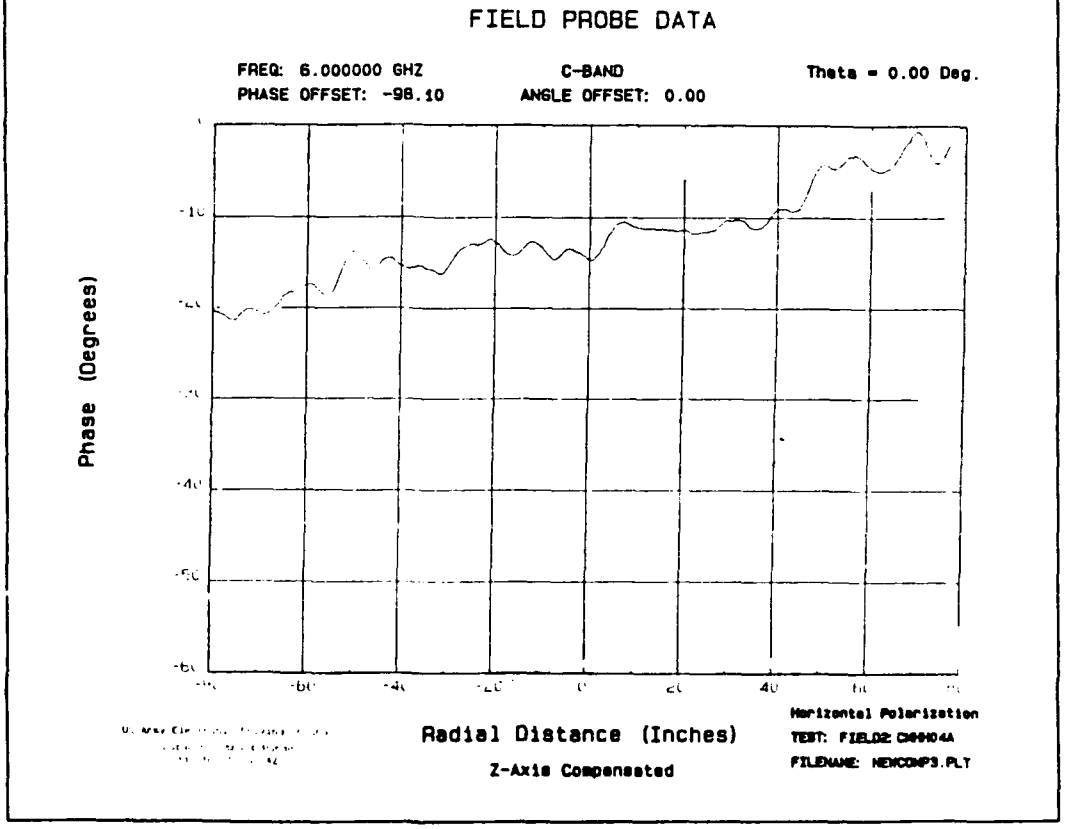
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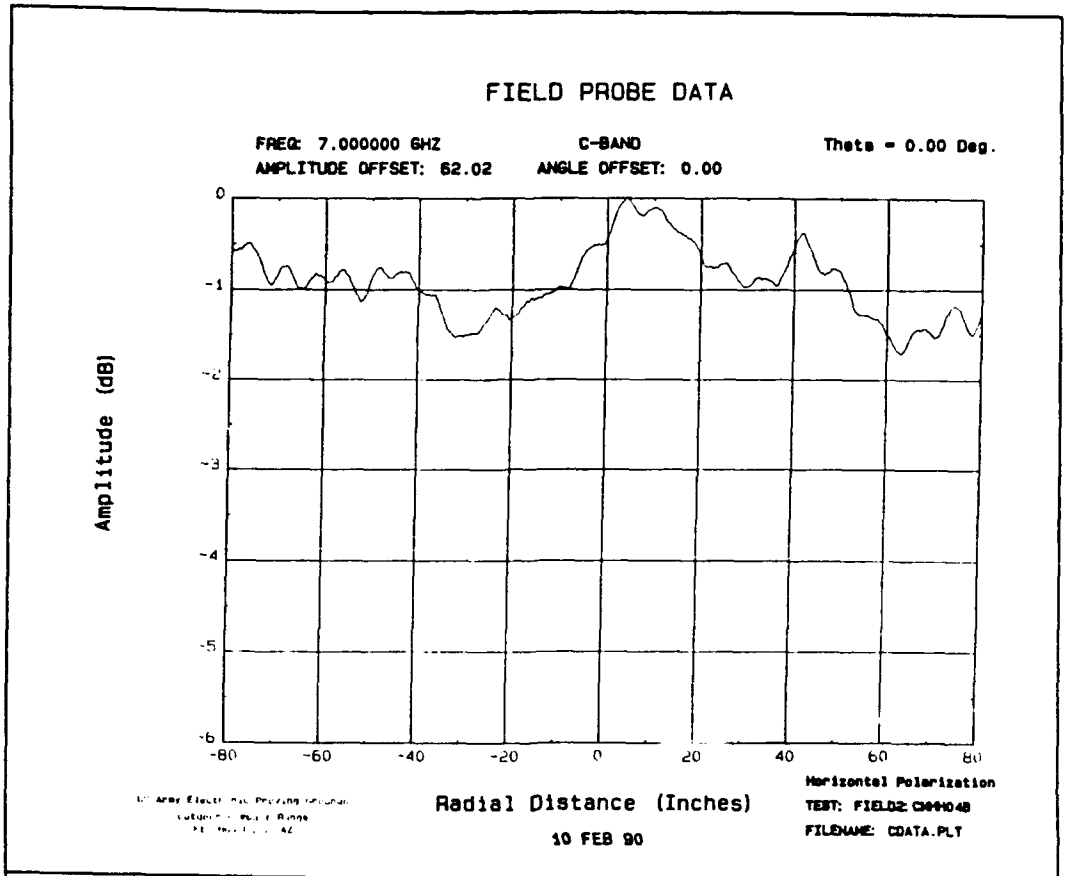
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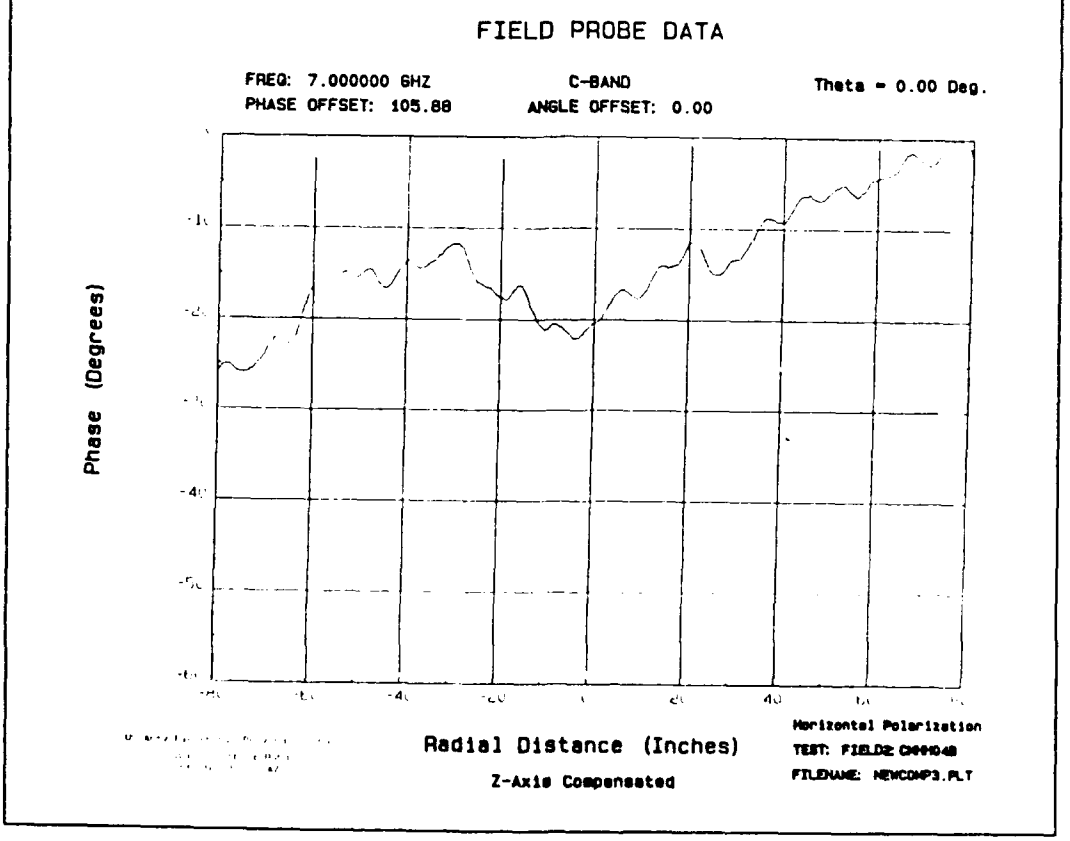
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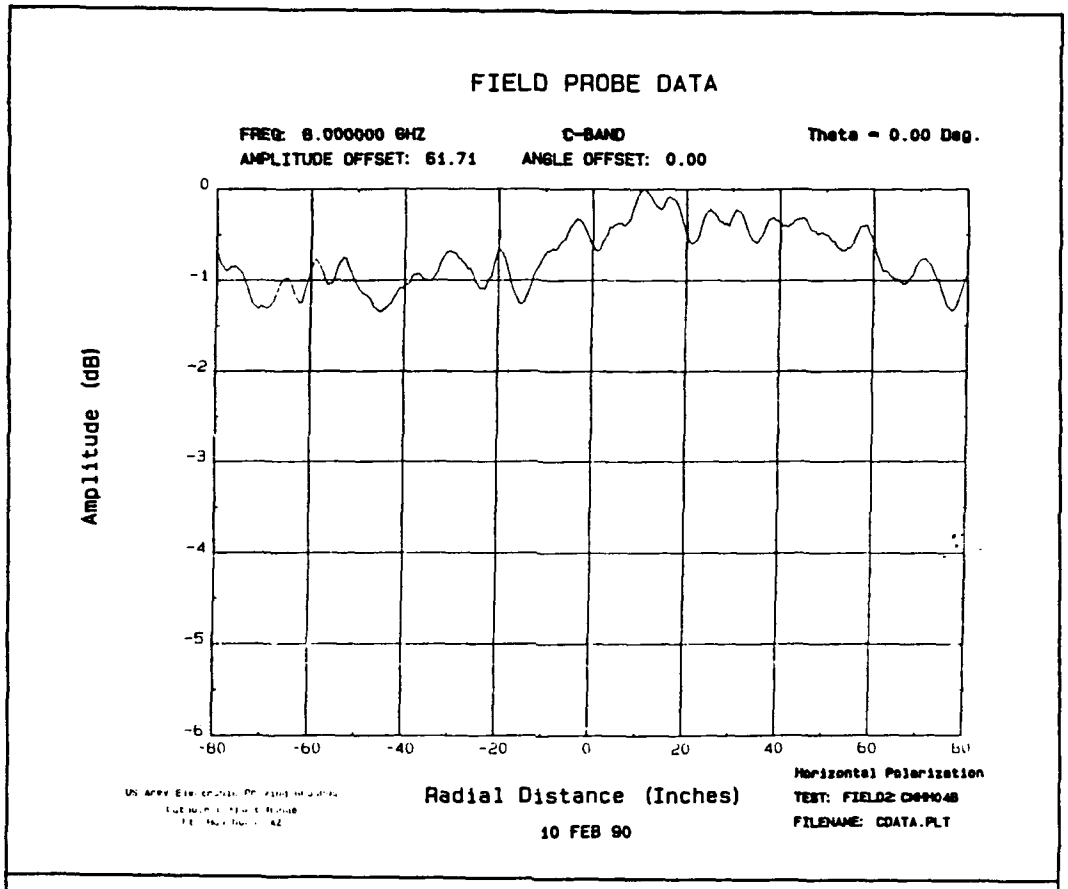
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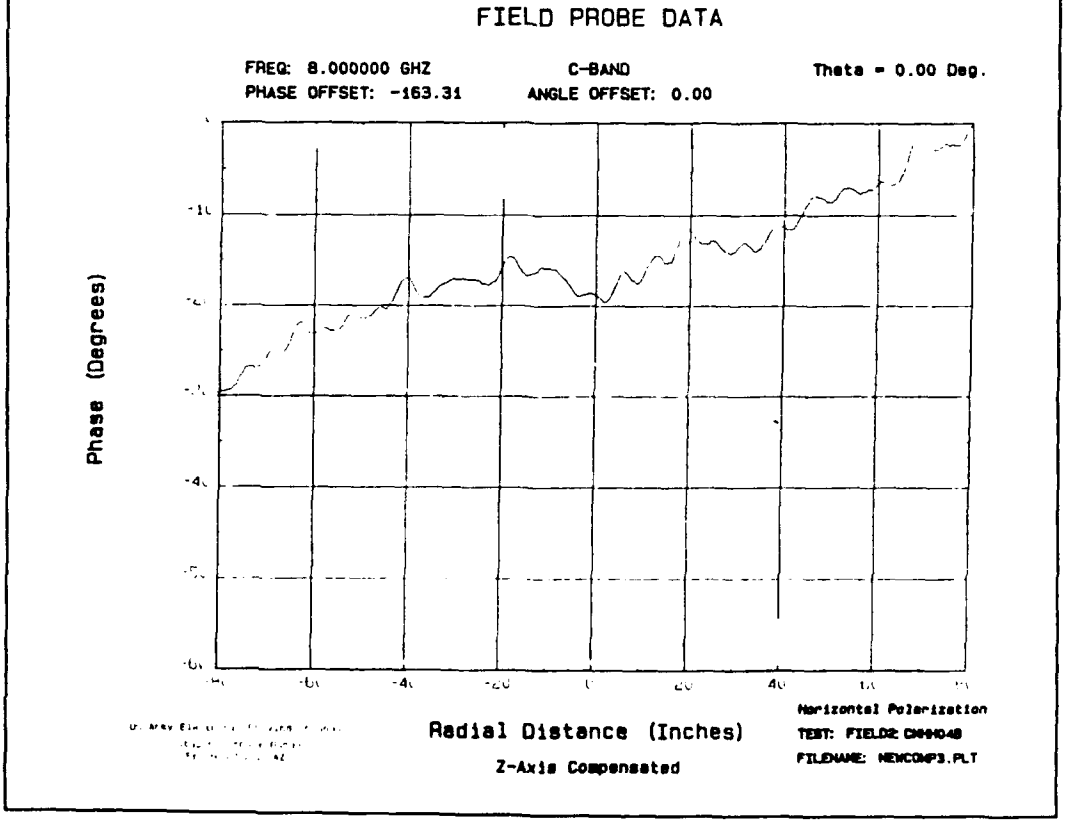
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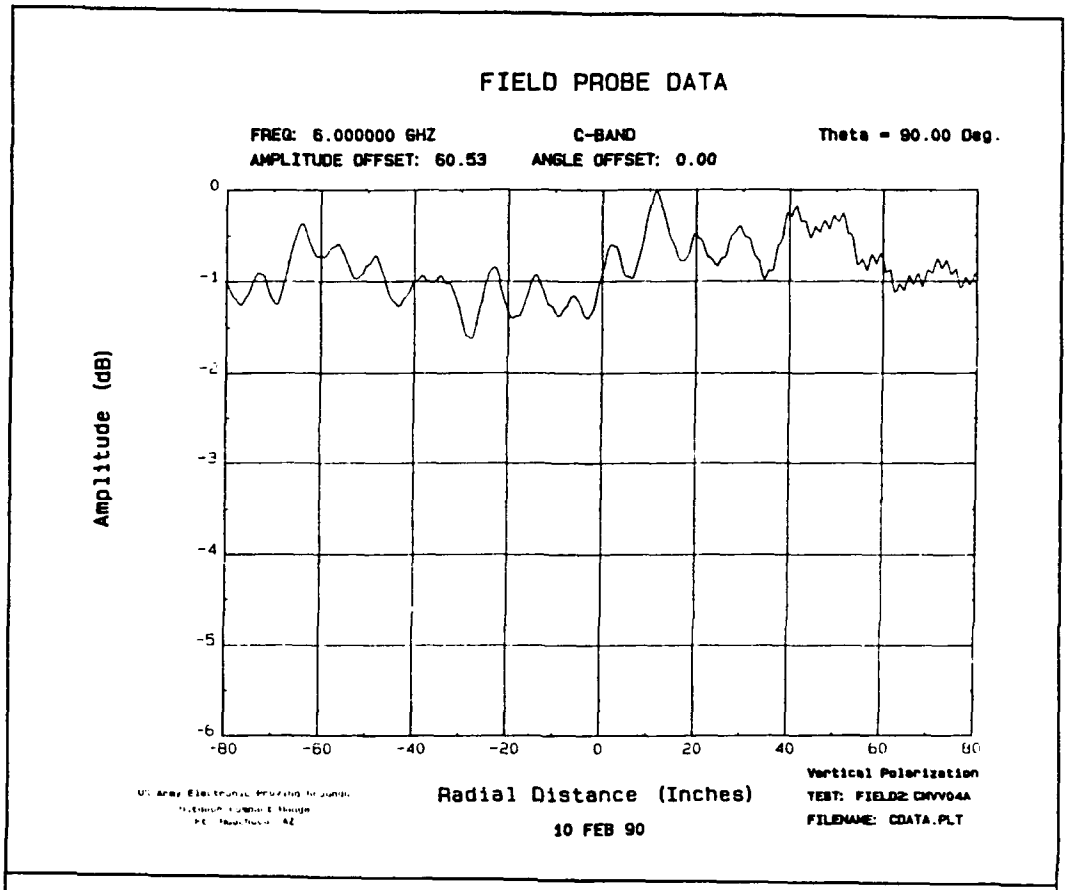
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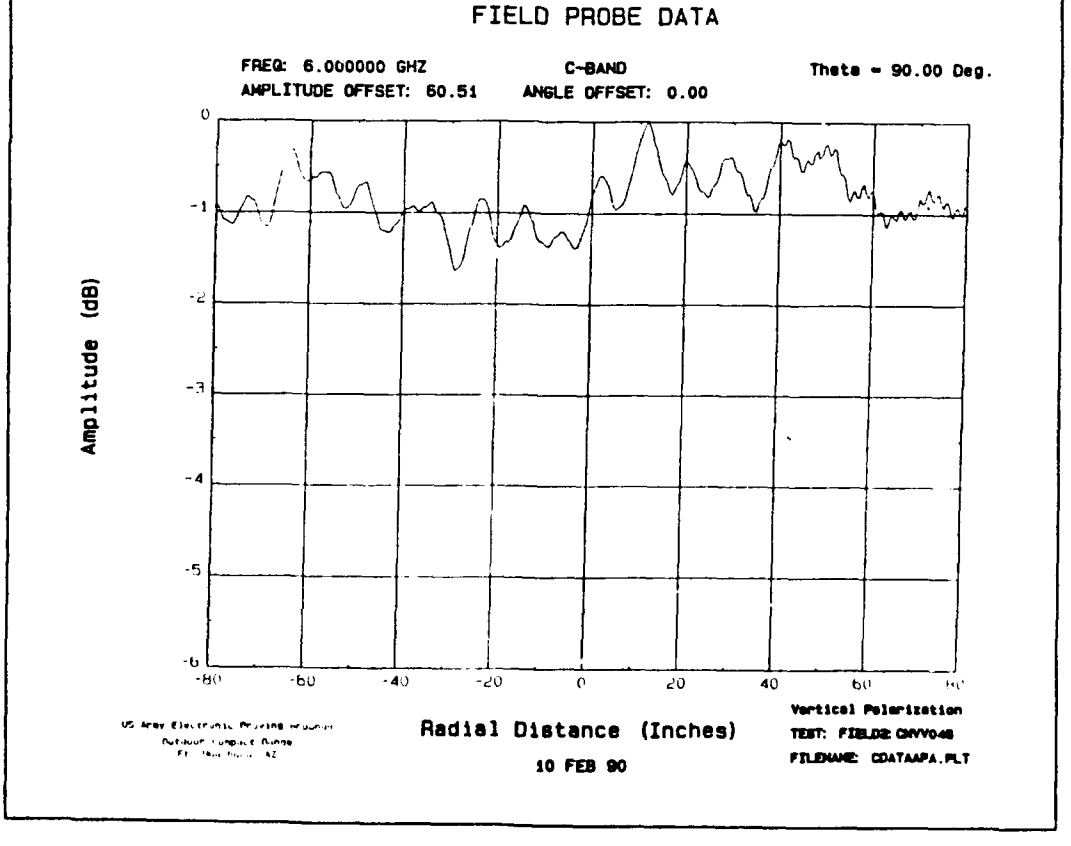
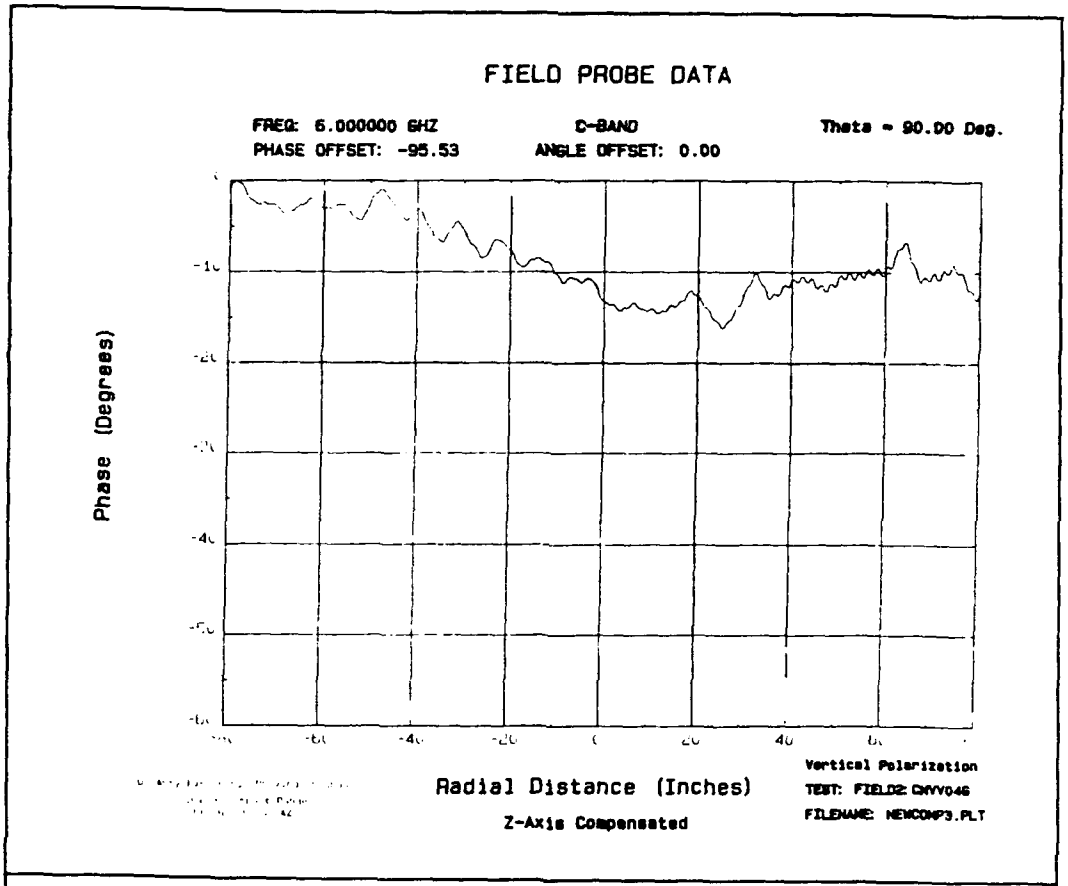
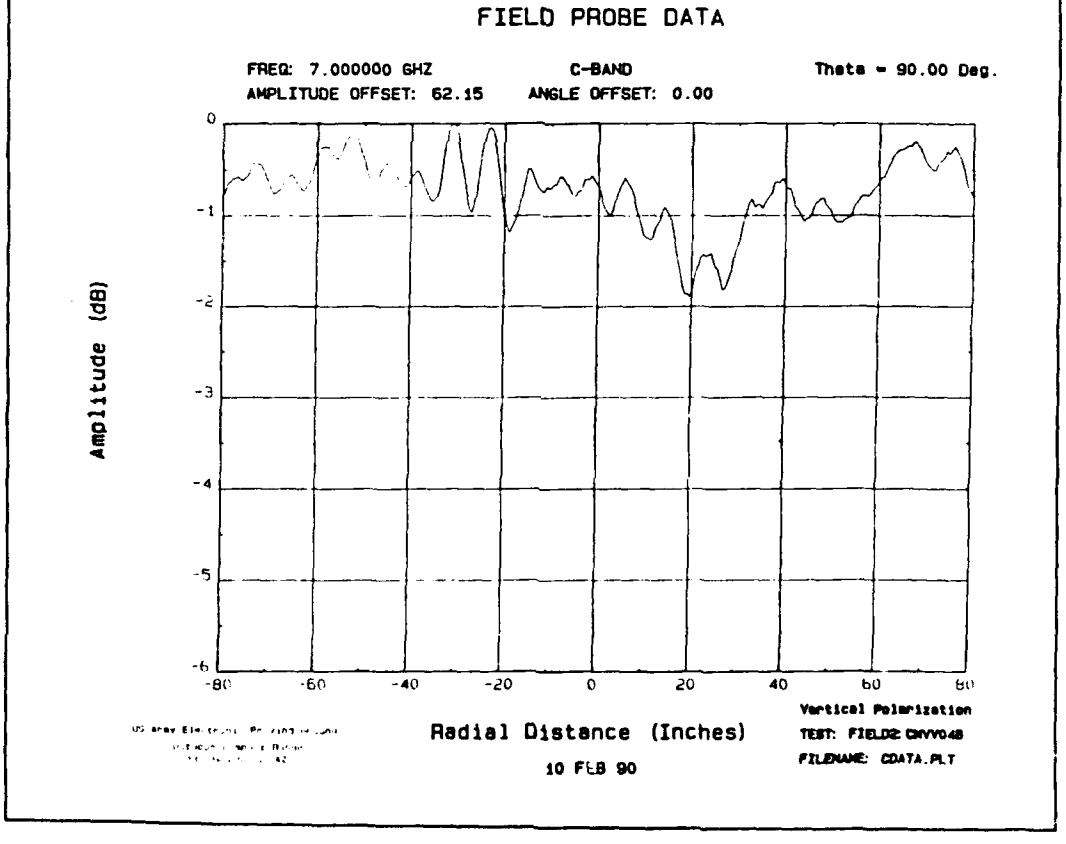
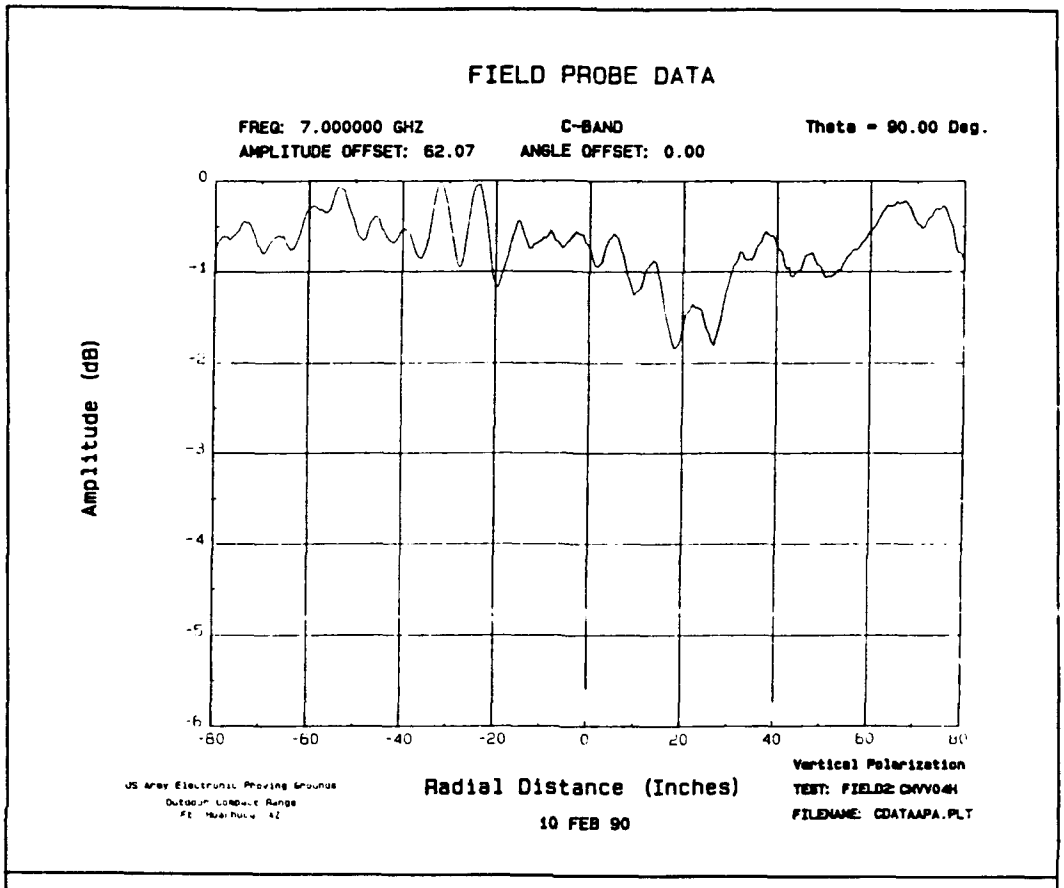
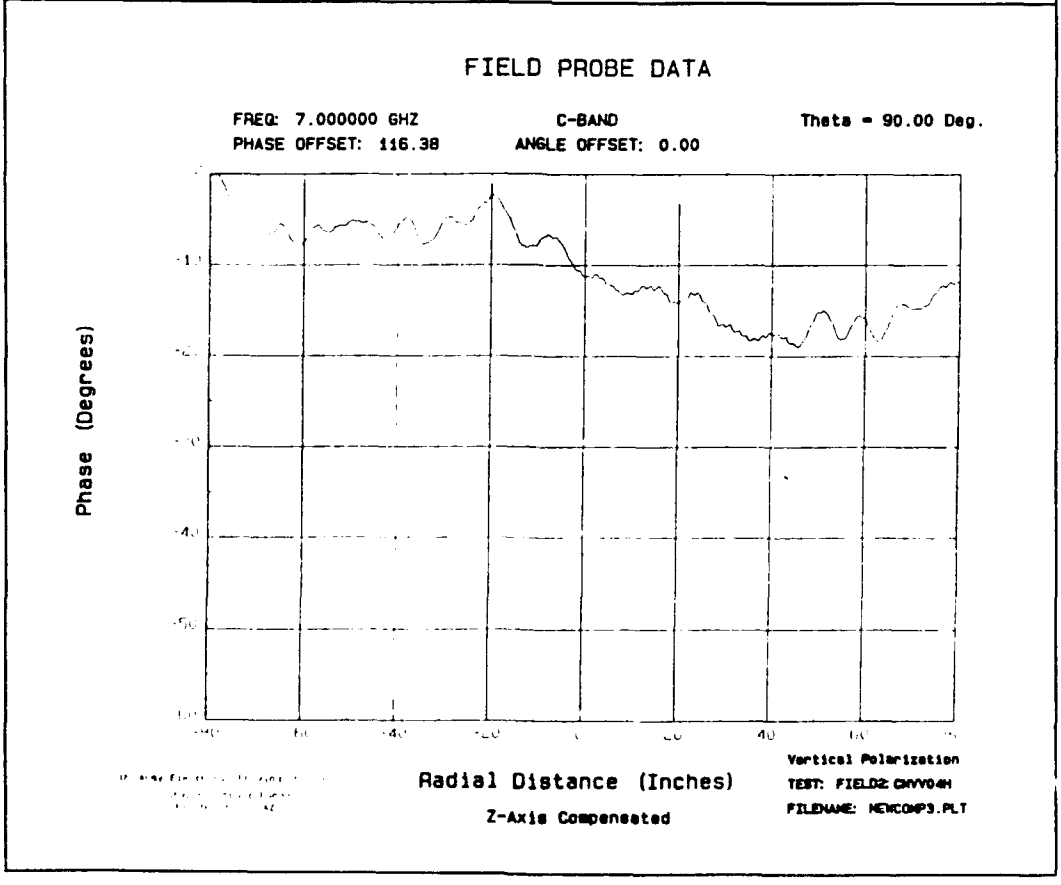
TEST: FIELD2 CHVV04A
FILENAME: CDATA.PLT

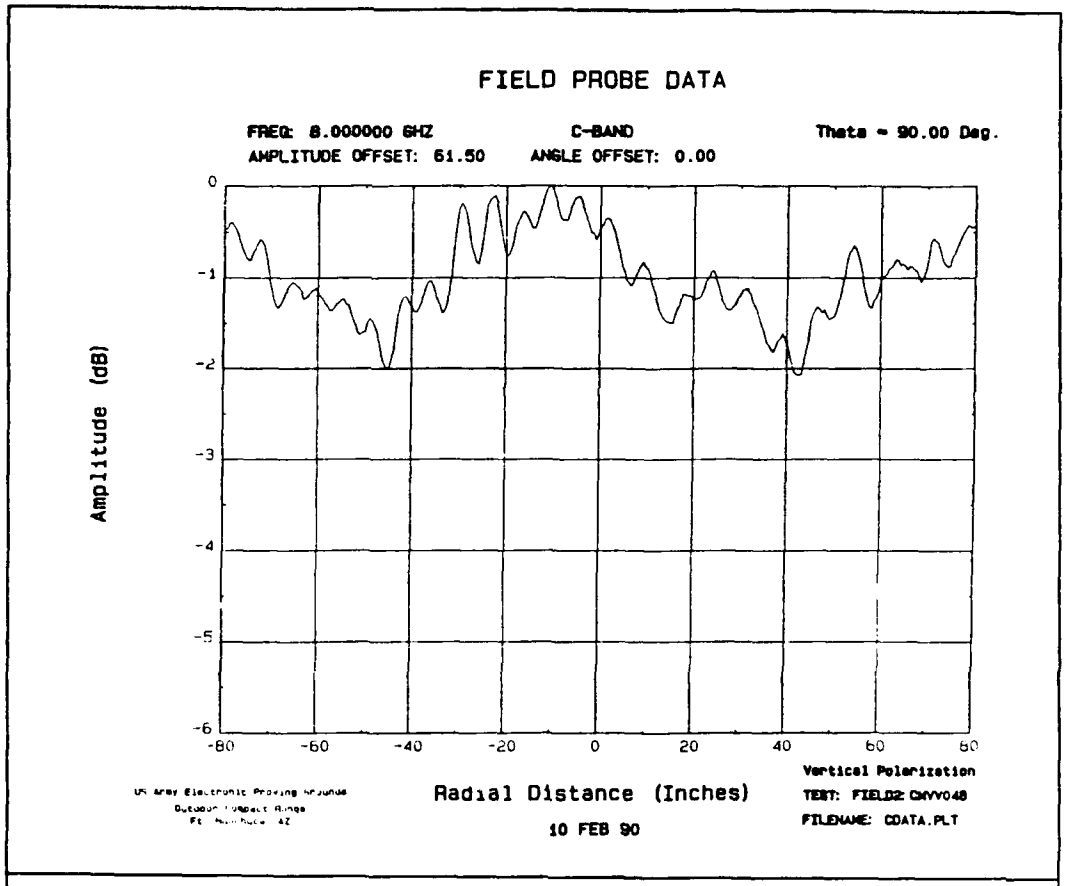

FIELD PROBE DATA
FREQ: 6.000000 GHZ
C-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 60.51
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
Radial Distance (Inches)
10 FEB 90
Vertical Polarization
TEST: FIELD2 CHVV04B
FILENAME: CDATAAPA.PLT

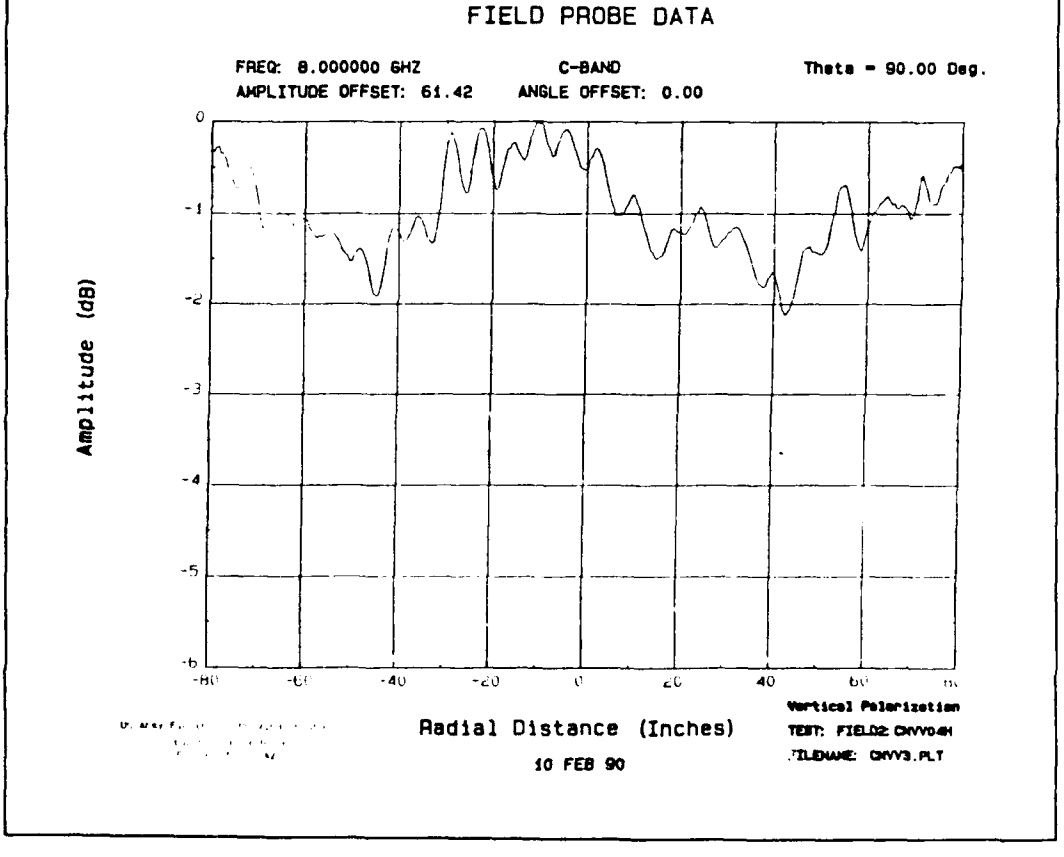

FIELD PROBE DATA
FREQ: 6.000000 GHZ
C-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -95.53
ANGLE OFFSET: 0.00
Phase (Degrees)
-10
-20
-40
-60
-80
-60
-40
-20
0
20
40
60
Radial Distance (Inches)
Z-Axis Compensated
Vertical Polarization
TEST: FIELD2 CHVV046
FILENAME: NEWCOMP3.PLT


FIELD PROBE DATA
FREQ: 7.000000 GHZ
C-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 62.15
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
10 FEB 90
Vertical Polarization
TEST: FIELD2 CHVV048
FILENAME: CDATA.PLT


FIELD PROBE DATA
FREQ: 7.000000 GHZ
C-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 62.07
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
10 FEB 90
Vertical Polarization
TEST: FIELD2 CHVV04H
FILENAME: CDATAAPA.PLT

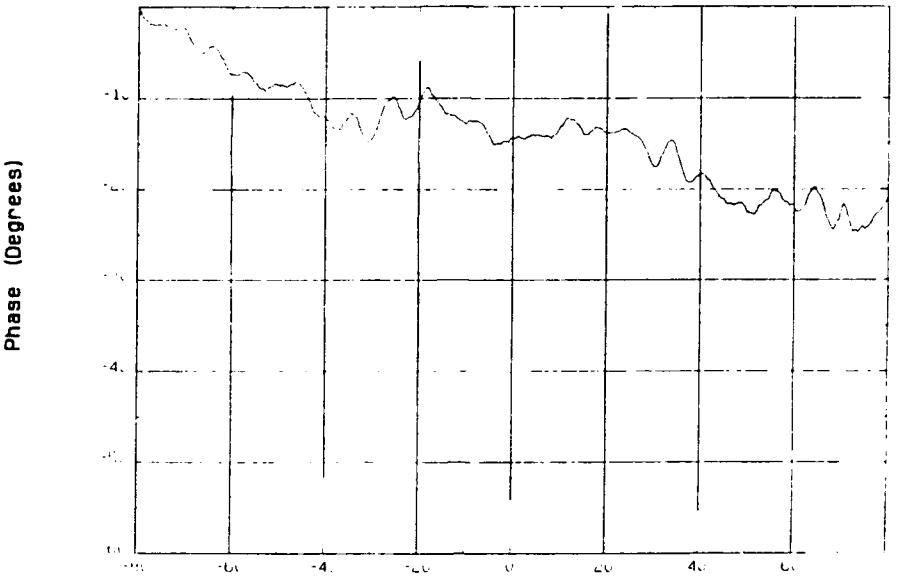

FIELD PROBE DATA
FREQ: 7.000000 GHZ
C-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 116.38
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
Z-Axis Compensated
Vertical Polarization
TEST: FIELD2 CHVV04H
FILENAME: NEWCOMP3.PLT


FIELD PROBE DATA
FREQ: 8.000000 GHZ
C-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 61.50
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
10 FEB 90
Vertical Polarization
TEST: FIELD2 CHVV048
FILENAME: CDATA.PLT


FIELD PROBE DATA
FREQ: 8.000000 GHZ
C-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 61.42
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-40
-20
40
Radial Distance (Inches)
10 FEB 90
Vertical Polarization
TEST: FIELD2 CHVV04H
FILENAME: CHVV3.PLT

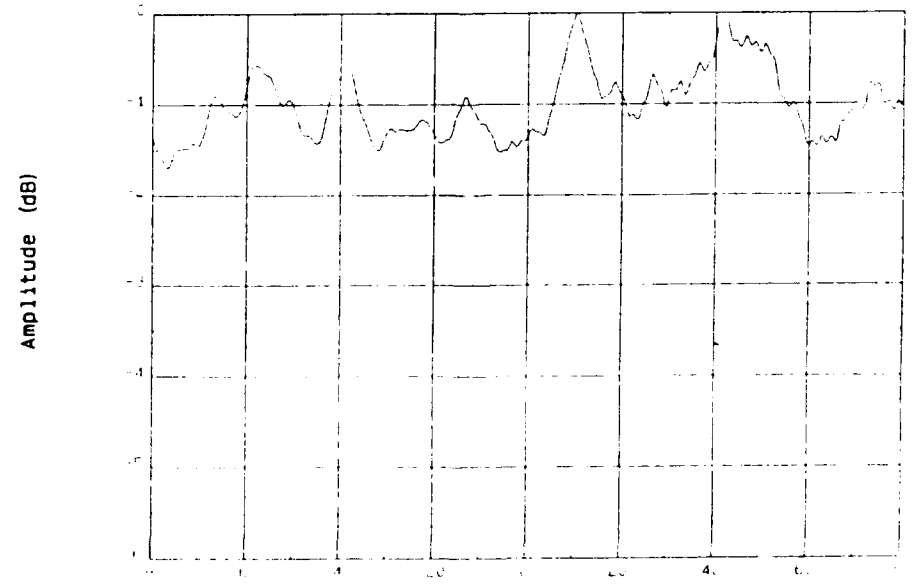
FIELD PROBE DATA

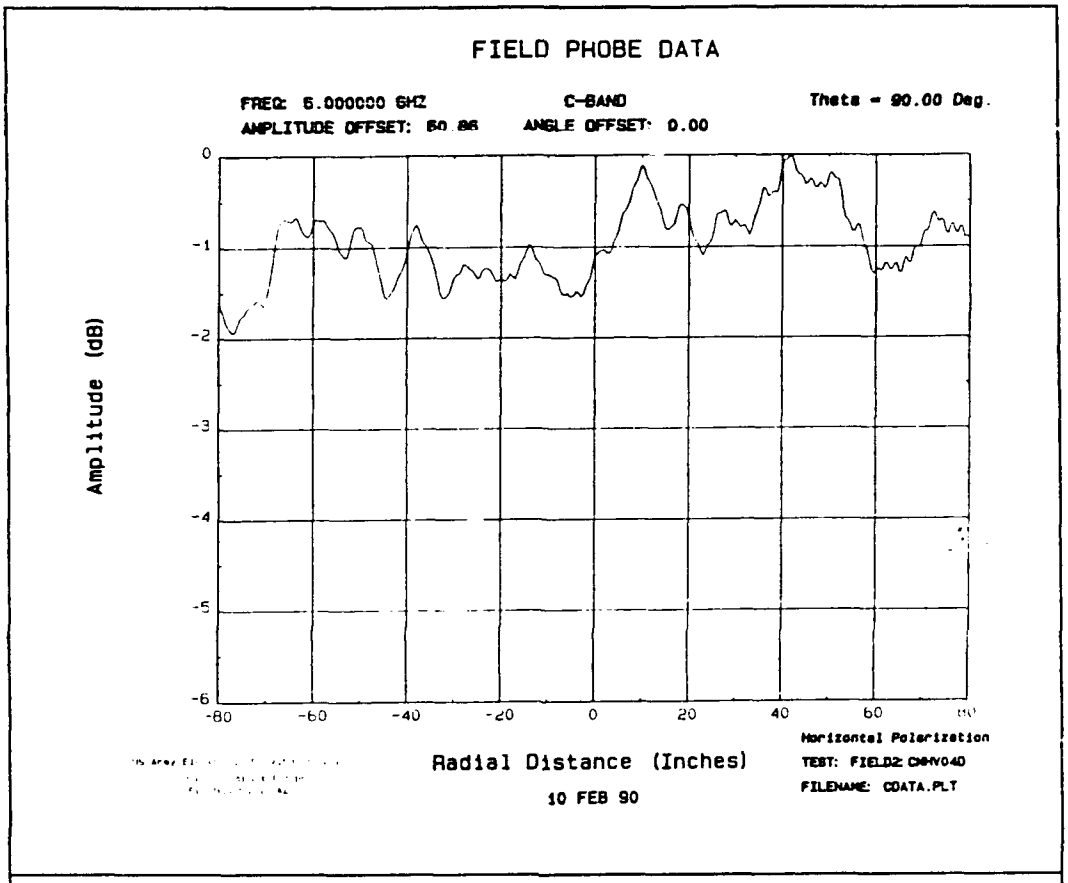
FREQ: 8.000000 GHZ C-BAND Theta = 90.00 Deg.
PHASE OFFSET: -153.49 ANGLE OFFSET: 0.00

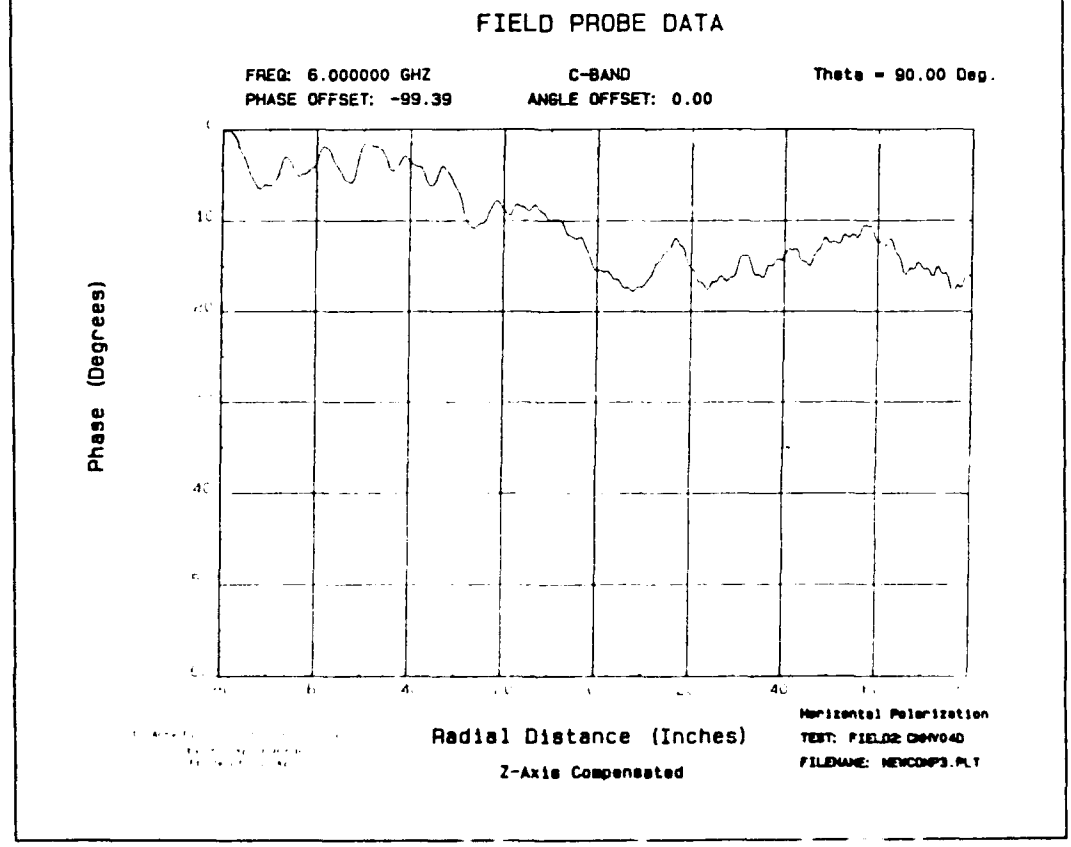


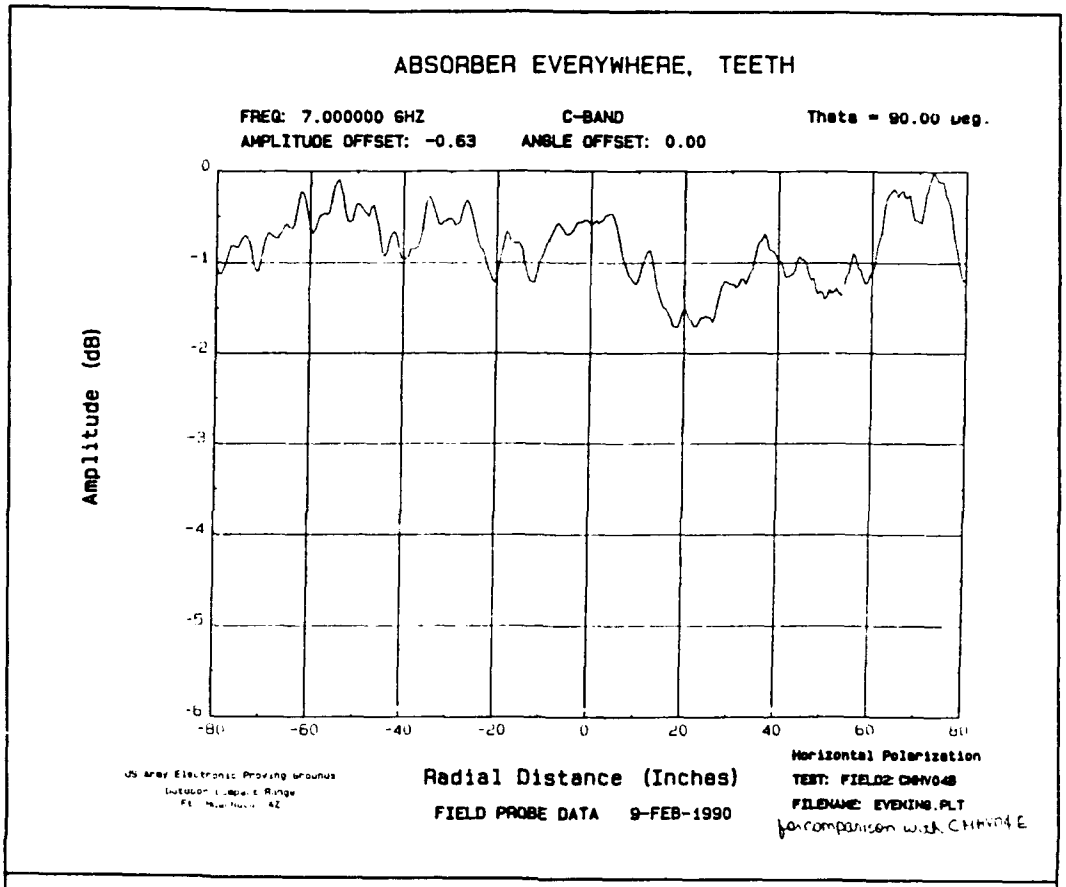
ABSORBER EVERYWHERE, TEETH

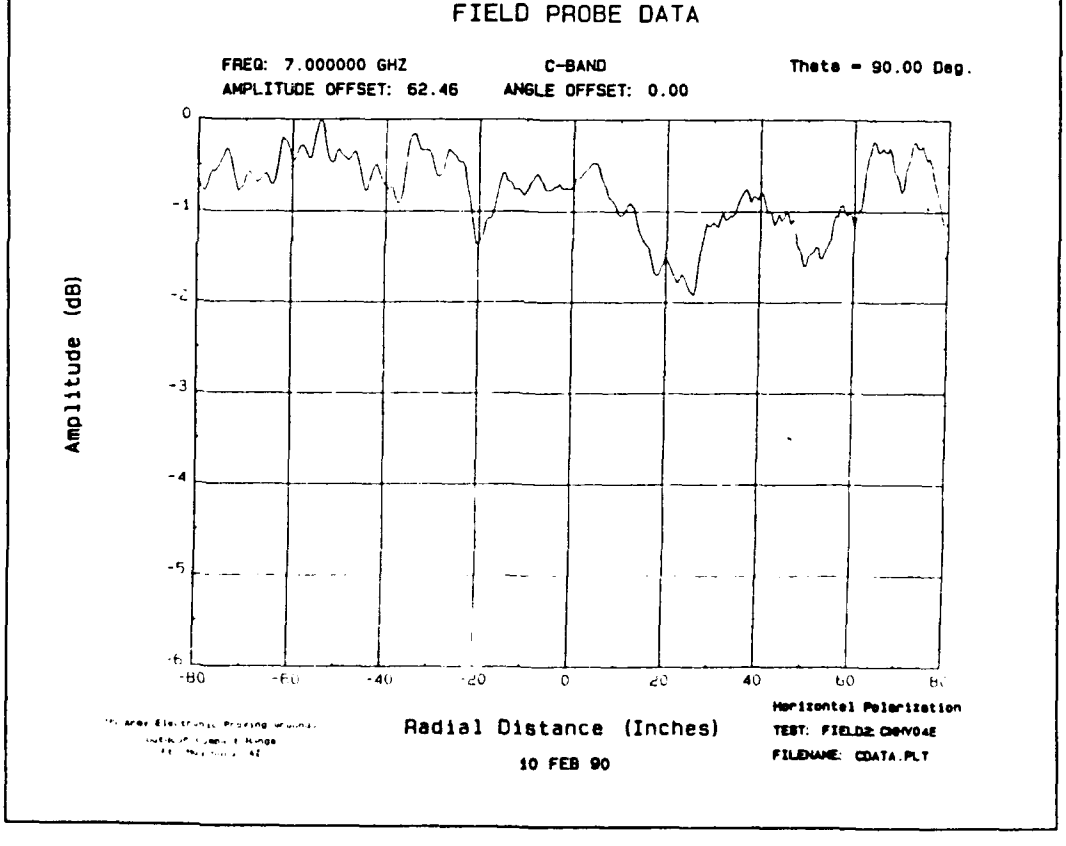
FREQ: 6.000000 GHZ C-BAND Theta = 90.00 Deg.
AMPLITUDE OFFSET: -1.28 ANGLE OFFSET: 0.00




FIELD PROBE DATA
FREQ: 6.000000 GHZ
C-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 50.86
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
Radial Distance (Inches)
10 FEB 90
Horizontal Polarization
TEST: FIELD2 CHHV040
FILENAME: CDATA.PLT

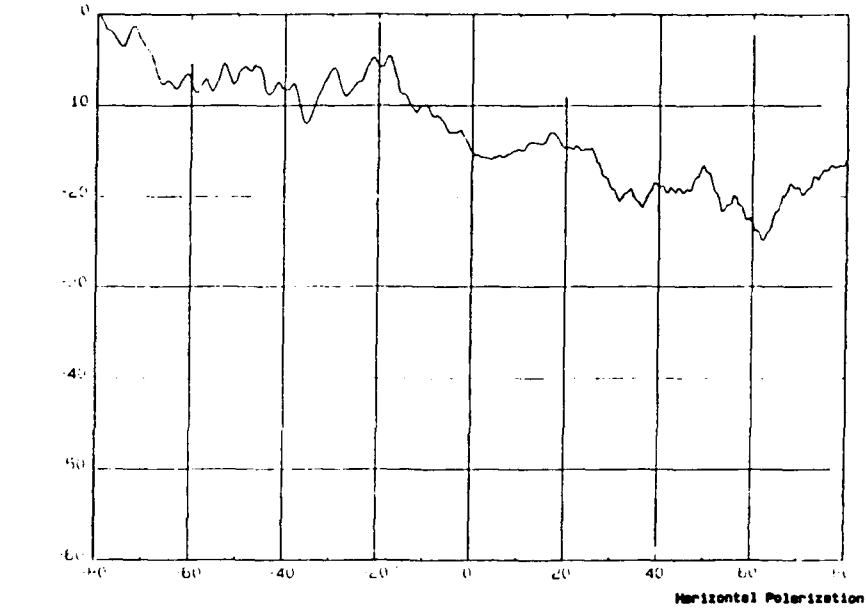

FIELD PROBE DATA
FREQ: 6.000000 GHZ
C-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -99.39
ANGLE OFFSET: 0.00
Phase (Degrees)
40
Radial Distance (Inches)
Z-Axis Compensated
Horizontal Polarization
TEST: FIELD2 CHHV040
FILENAME: NEWCOMP3.PLT


ABSORBER EVERYWHERE, TEETH
FREQ: 7.000000 GHZ
C-BAND
Theta = 90.00 deg.
AMPLITUDE OFFSET: -0.63
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
FIELD PROBE DATA 9-FEB-1990
Horizontal Polarization
TEST: FIELD2 CHHV04B
FILENAME: EVENING.PLT
for comparison with CHHV04E


FIELD PROBE DATA
FREQ: 7.000000 GHZ
C-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 62.46
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
Radial Distance (Inches)
10 FEB 90
Horizontal Polarization
TEST: FIELD2 CHHV04E
FILENAME: CDATA.PLT

FIELD PROBE DATA

FREQ: 7.000000 GHZ C-BAND Theta = 90.00 Deg.
PHASE OFFSET: 104.12 ANGLE OFFSET: 0.00



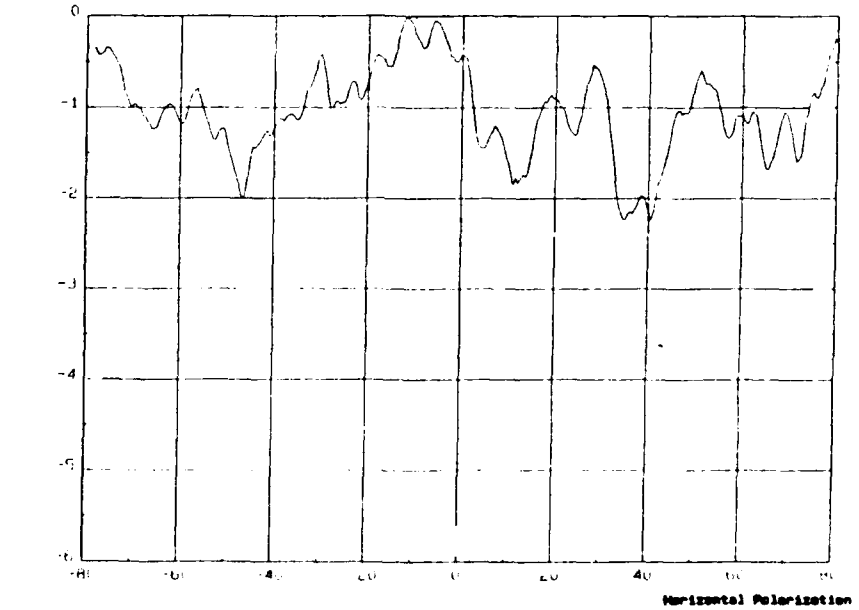
Radial Distance (Inches)

Z-Axis Compensated

Horizontal Polarization
TEST: FIELD2 C6HV04E
FILENAME: NEWCOMP3.PLT

ABSORBER EVERYWHERE, TEETH

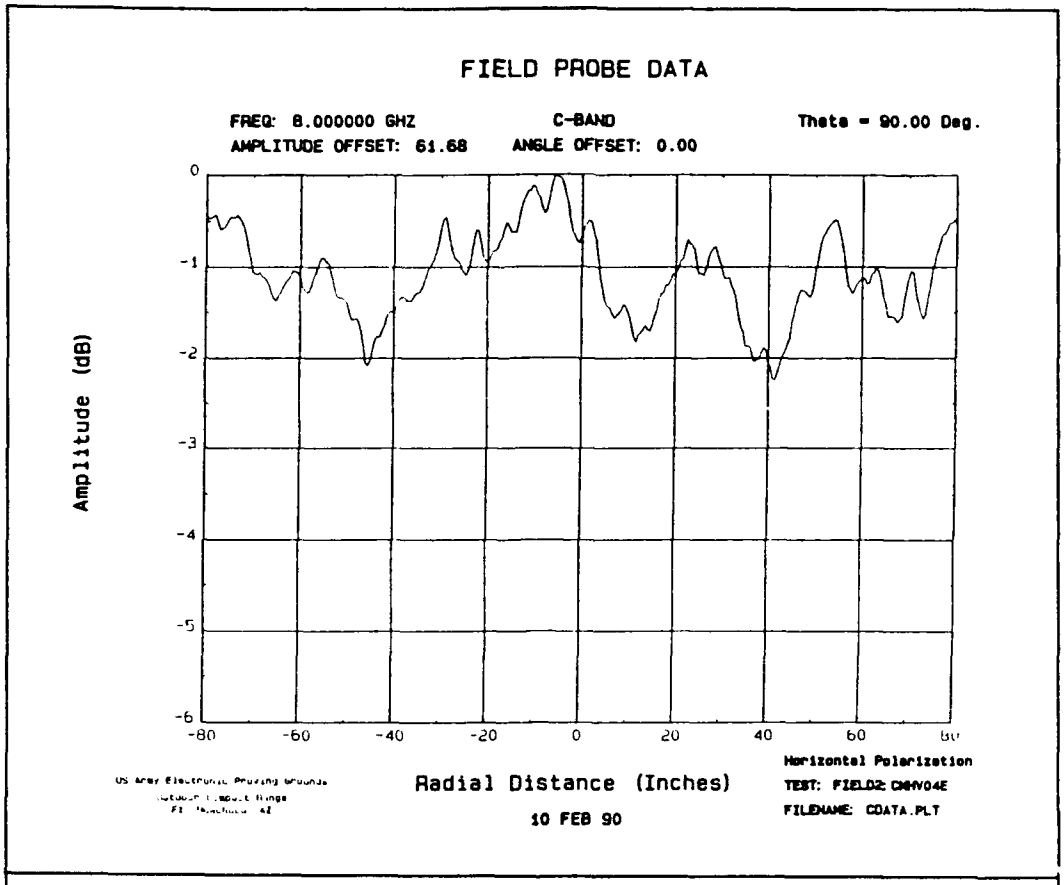
FREQ: 8.000000 GHZ C-BAND Theta = 90.00 Deg.
AMPLITUDE OFFSET: -0.46 ANGLE OFFSET: 0.00

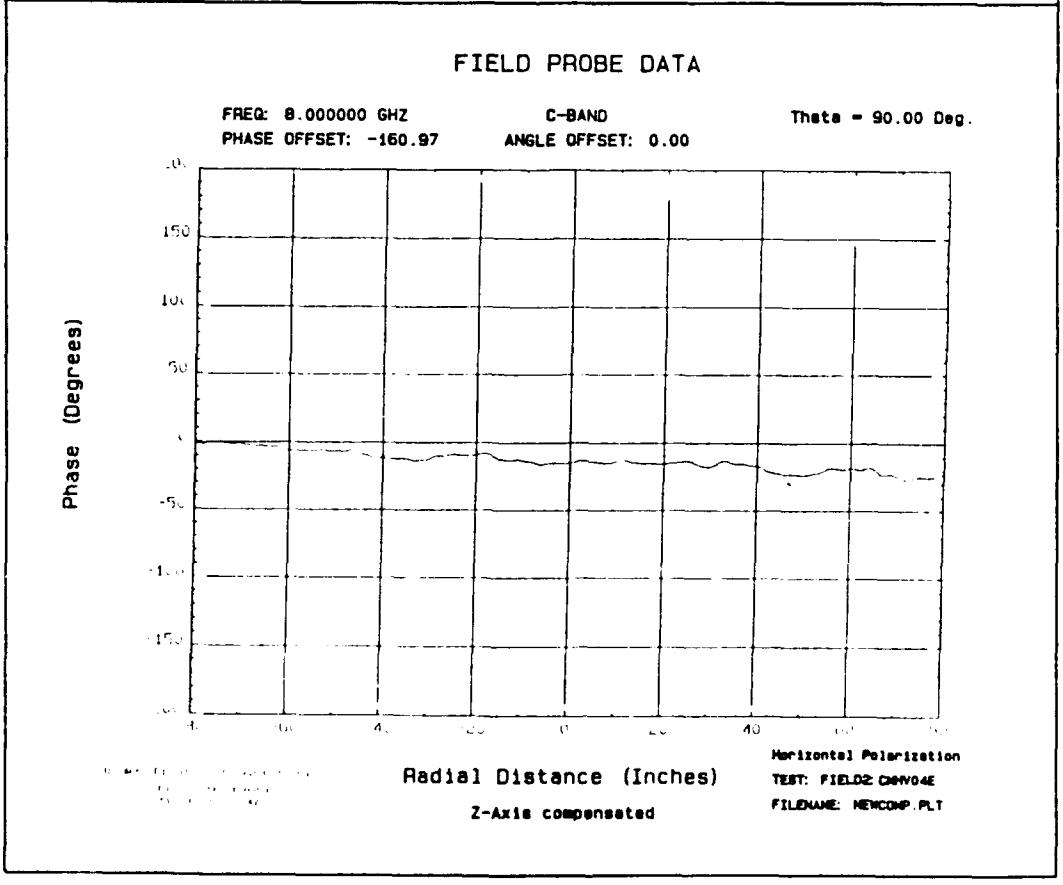


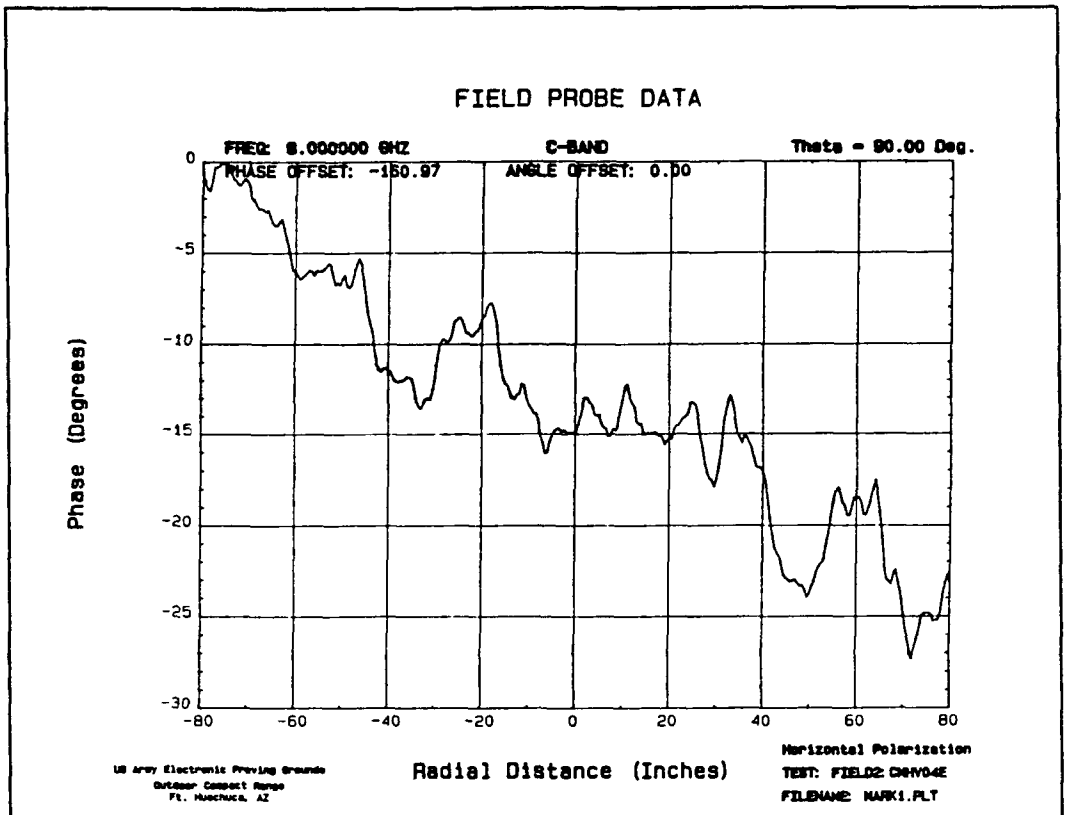
Radial Distance (Inches)

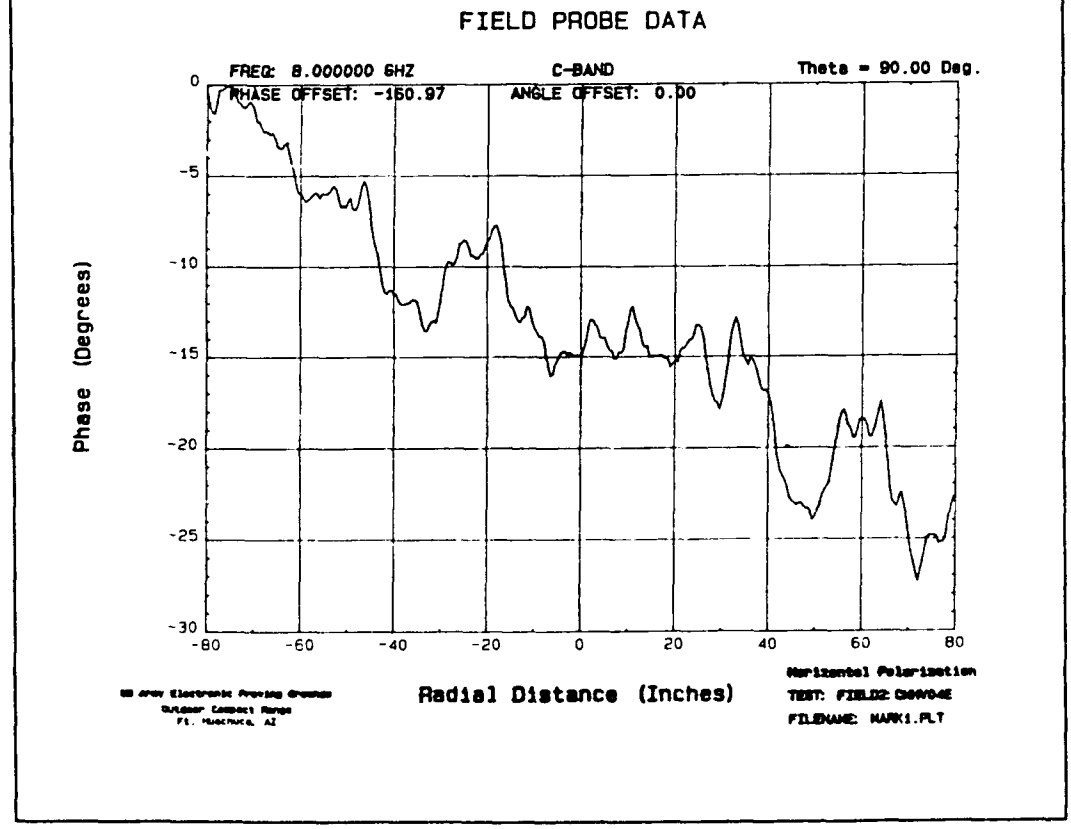
FIELD PROBE DATA 9-FEB-1990

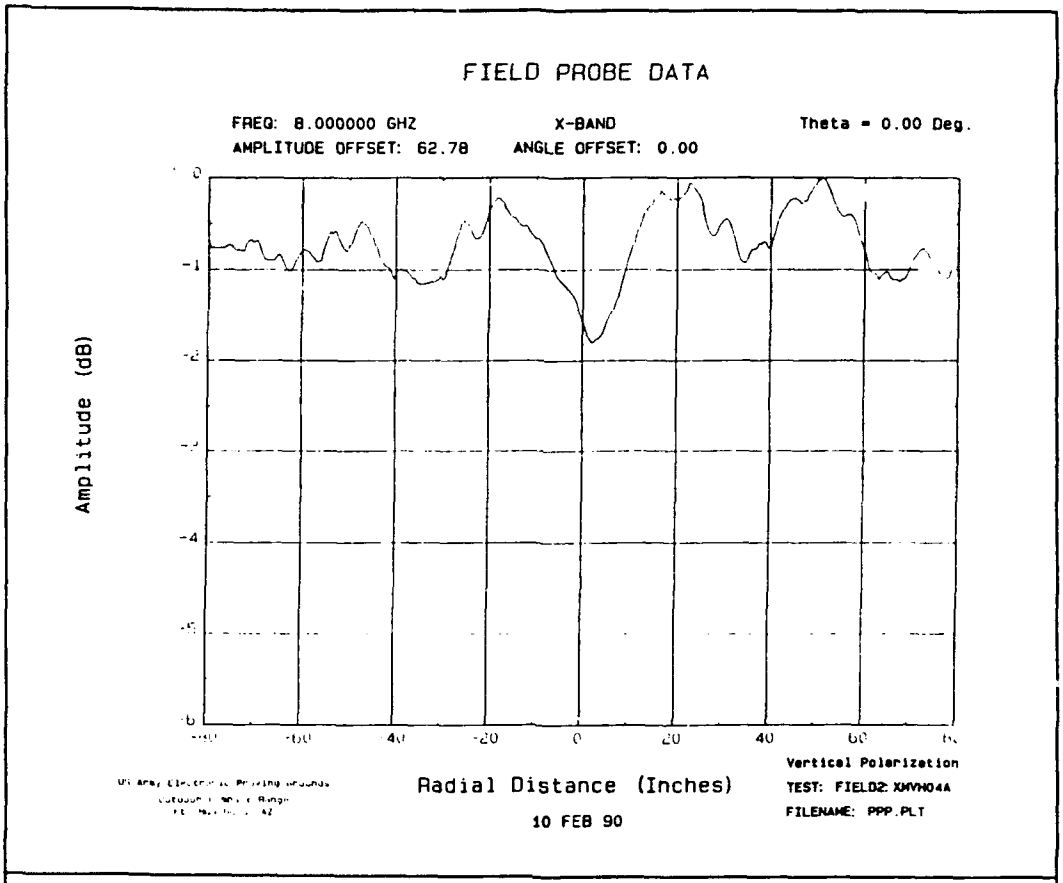
Horizontal Polarization
TEST: FIELD2 C6HV04B
FILENAME: EVENING.PLT

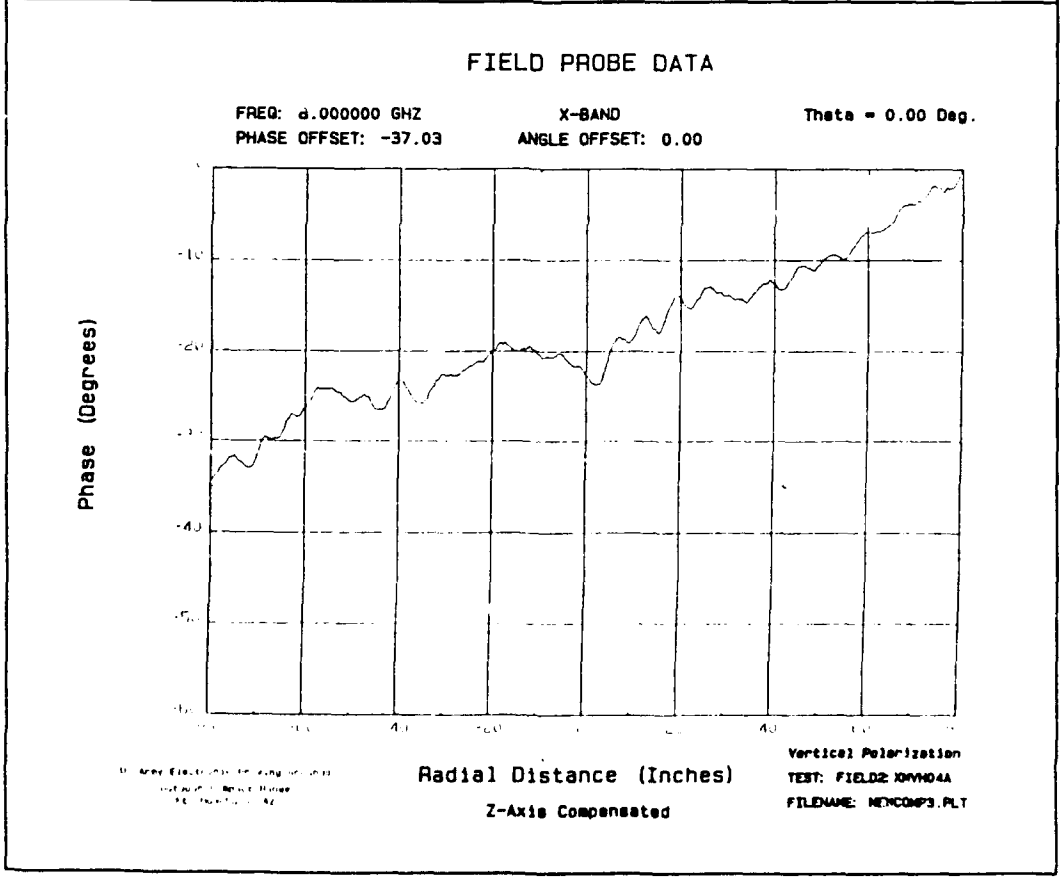

FIELD PROBE DATA
FREQ: 8.000000 GHZ
C-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 61.68
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
Radial Distance (Inches)
10 FEB 90
Horizontal Polarization
TEST: FIELD2 CHHV04E
FILENAME: CDATA.PLT

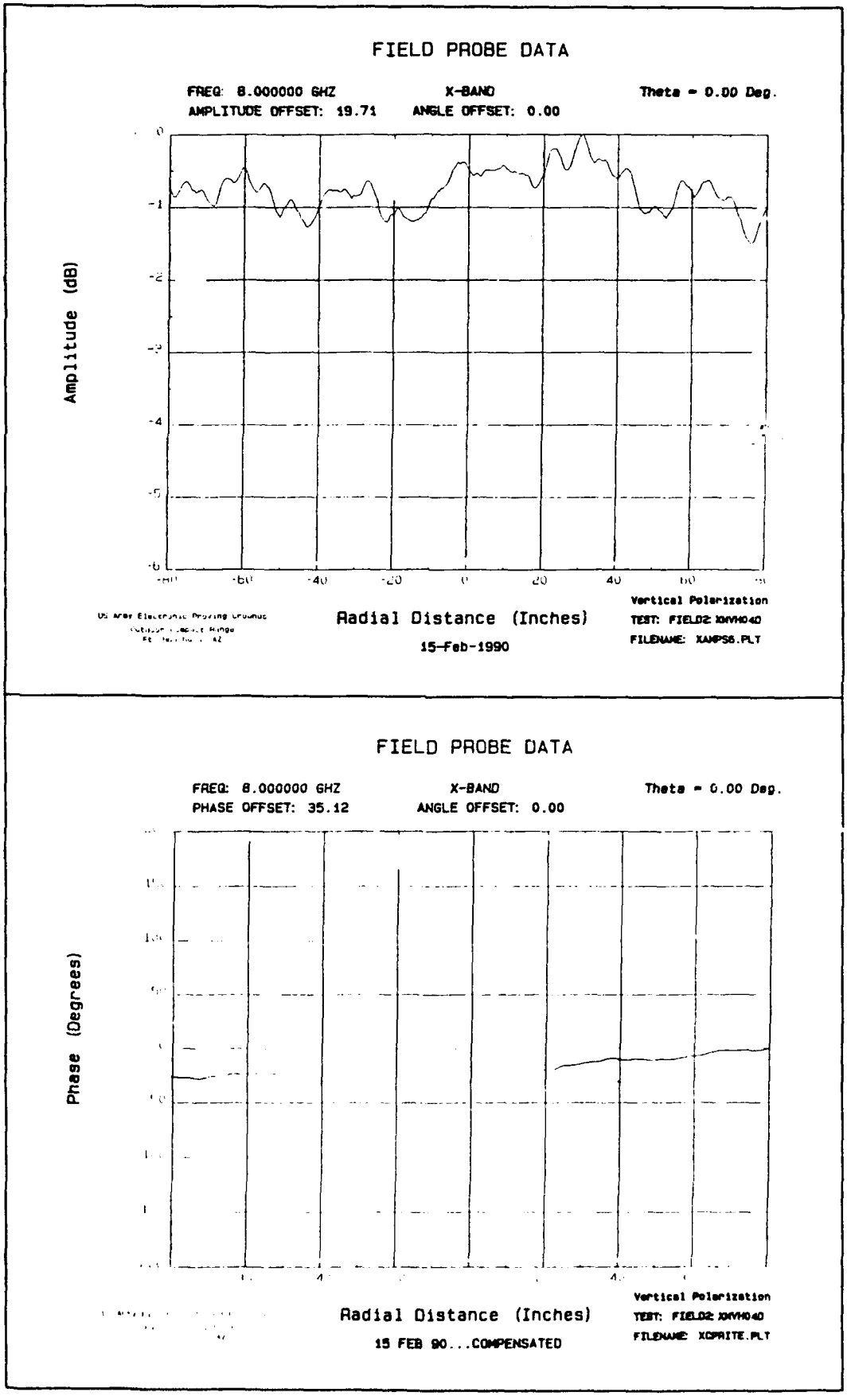

FIELD PROBE DATA
FREQ: 8.000000 GHZ
C-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -160.97
ANGLE OFFSET: 0.00
Phase (Degrees)
150
100
50
-50
-100
-150
40
Radial Distance (Inches)
Z-Axis compensated
Horizontal Polarization
TEST: FIELD2 CHHV04E
FILENAME: NEWCOMP.PLT

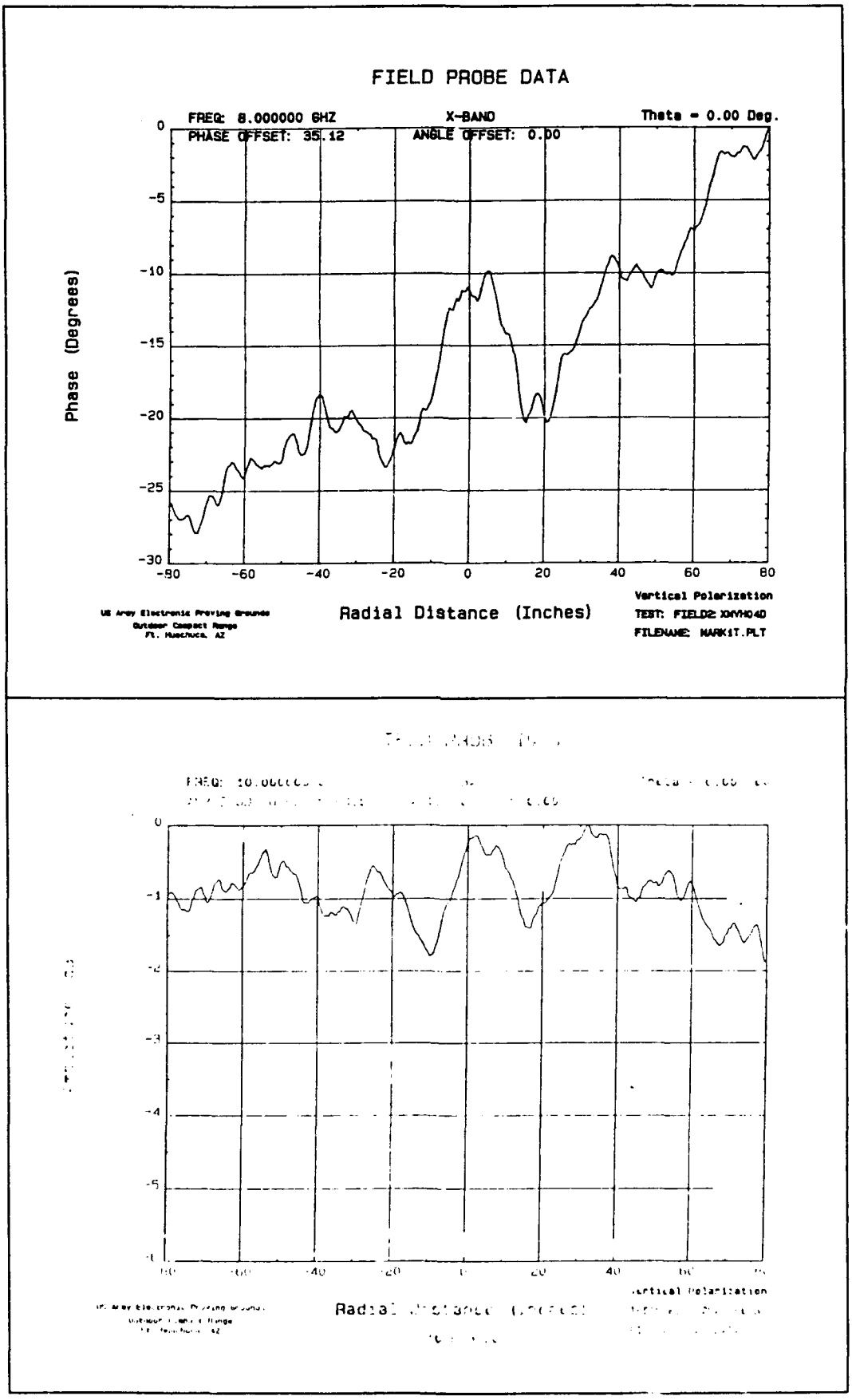

FIELD PROBE DATA
FREQ: 8.000000 GHZ
C-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -150.97
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 CHHV04E
FILENAME: MARK1.PLT

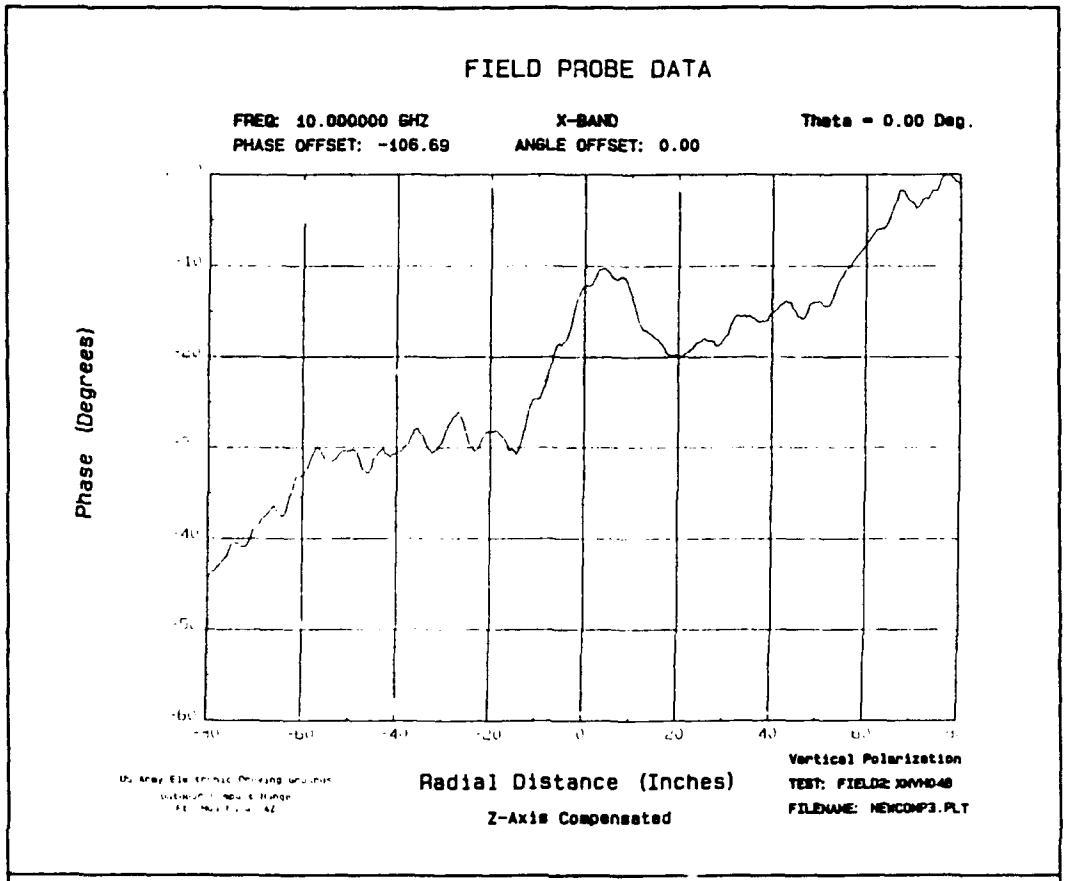

FIELD PROBE DATA
FREQ: 8.000000 GHZ
C-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -150.97
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 CHHV04E
FILENAME: MARK1.PLT

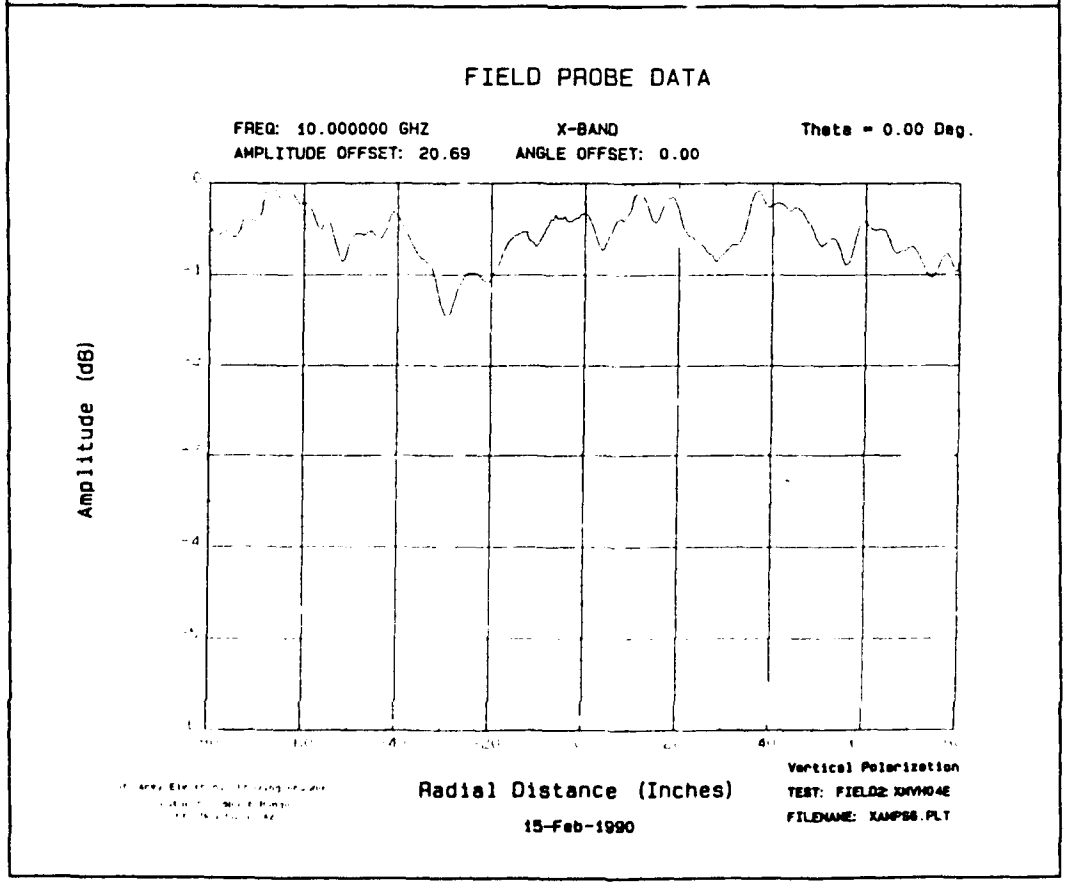

FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 62.78
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-4
-6
-60
-40
-20
0
20
40
60
Radial Distance (Inches)
10 FEB 90
Vertical Polarization
TEST: FIELD2 XMVH04A
FILENAME: PPP.PLT

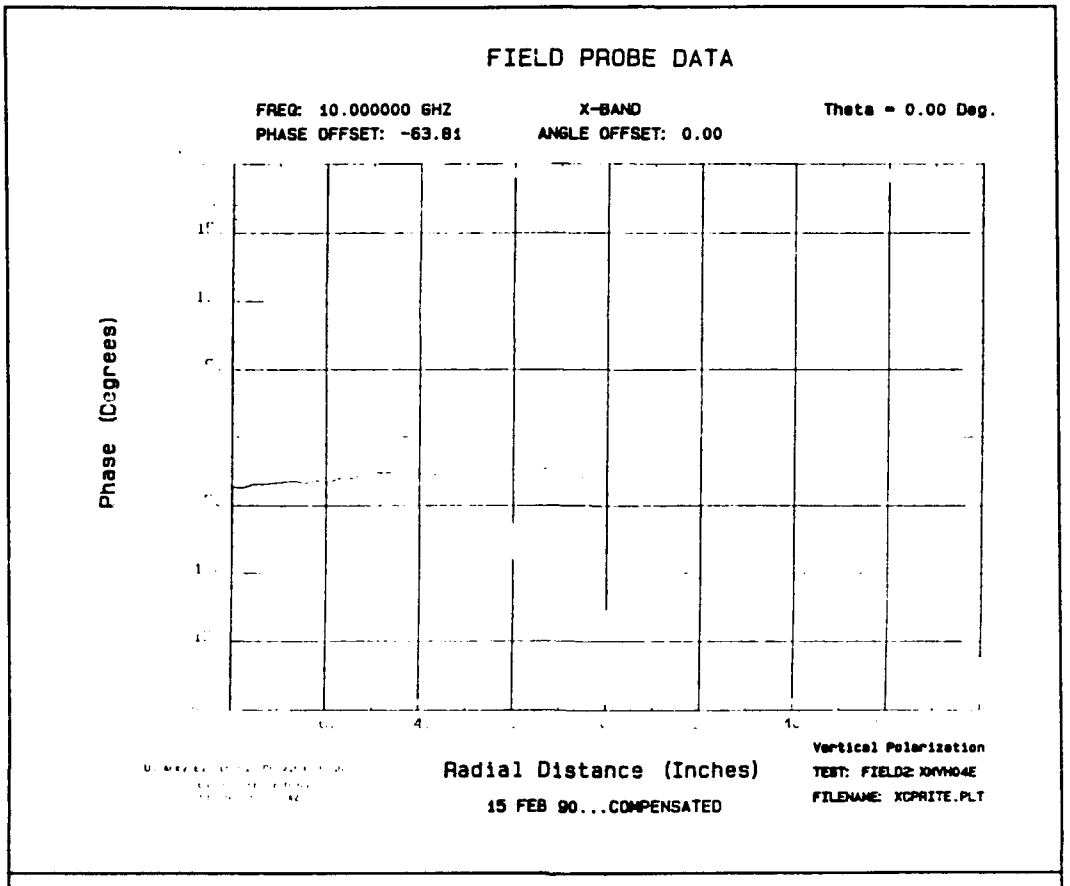

FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -37.03
ANGLE OFFSET: 0.00
Phase (Degrees)
-40
-60
Radial Distance (Inches)
Z-Axis Compensated
Vertical Polarization
TEST: FIELD2 XMVH04A
FILENAME: NEWCOMP3.PLT

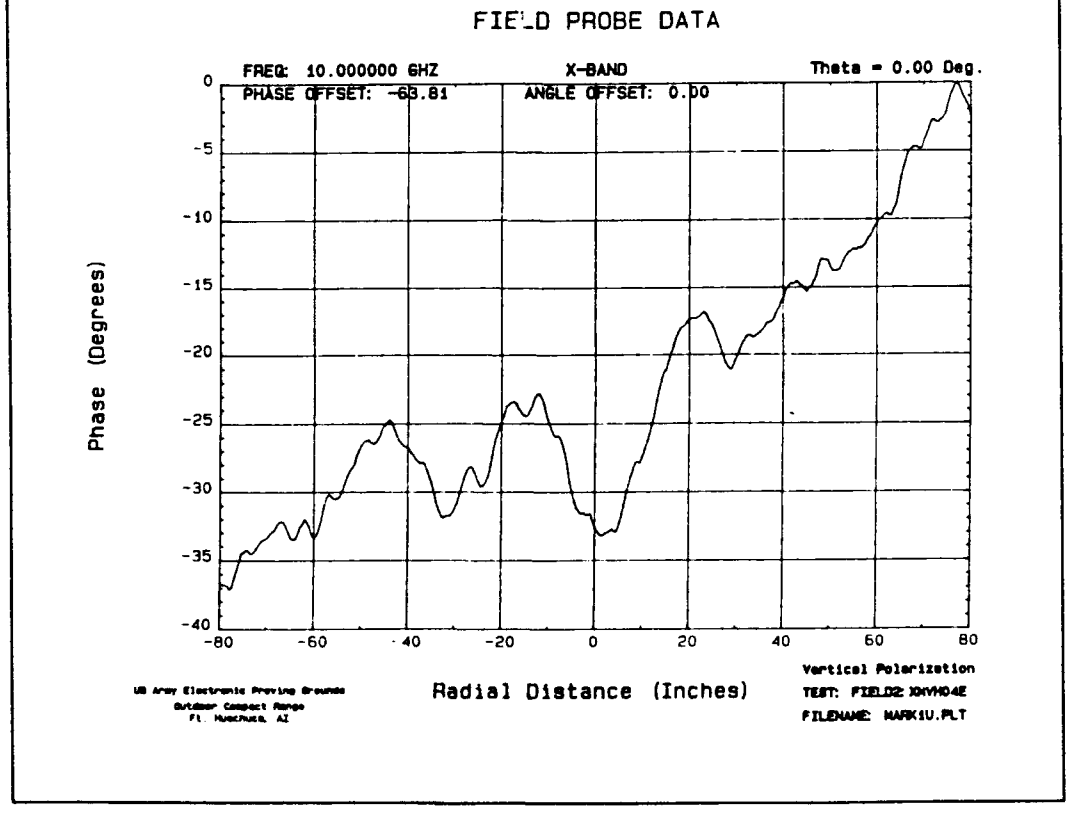

FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 19.71
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
Radial Distance (Inches)
15-Feb-1990
Vertical Polarization
TEST: FIELD2 XHVH040
FILENAME: XAMPS6.PLT
FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 35.12
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
15 FEB 90...COMPENSATED
Vertical Polarization
TEST: FIELD2 XHVH040
FILENAME: XCPRITE.PLT

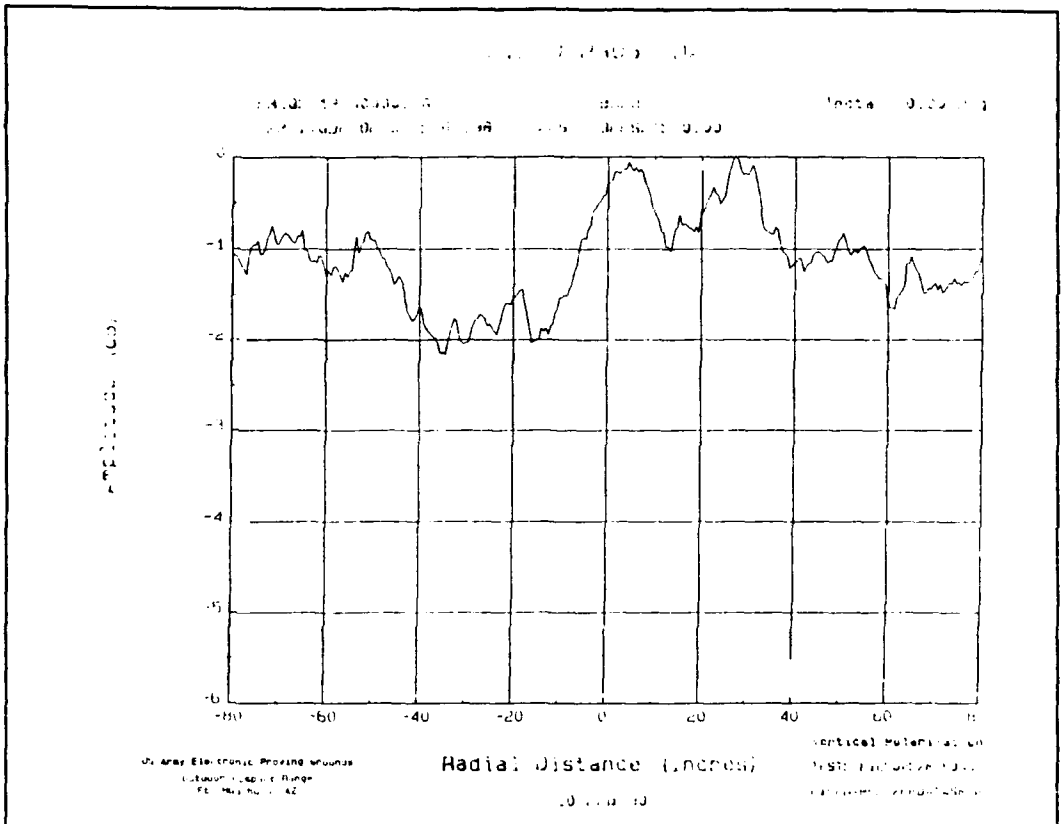

FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 35.12
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2 XMVH040
FILENAME: MARK1T.PLT


FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -106.69
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
Z-Axis Compensated
Vertical Polarization
TEST: FIELD2 XHVH048
FILENAME: NEWCOMP3.PLT


FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 20.69
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
15-Feb-1990
Vertical Polarization
TEST: FIELD2 XHVH04E
FILENAME: XAMPS6.PLT

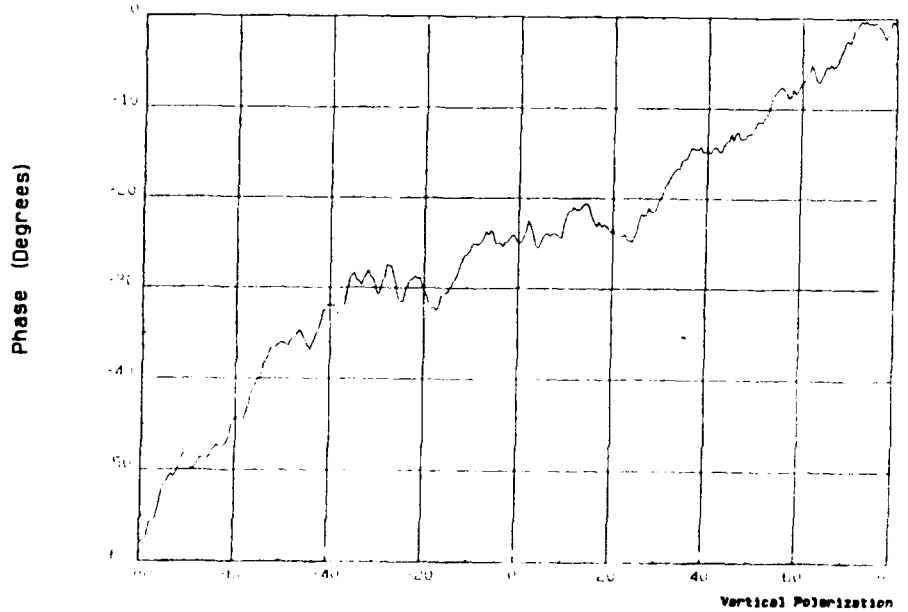

FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -63.81
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
15 FEB 90...COMPENSATED
Vertical Polarization
TEST: FIELD2 XHVH04E
FILENAME: XCPRITE.PLT

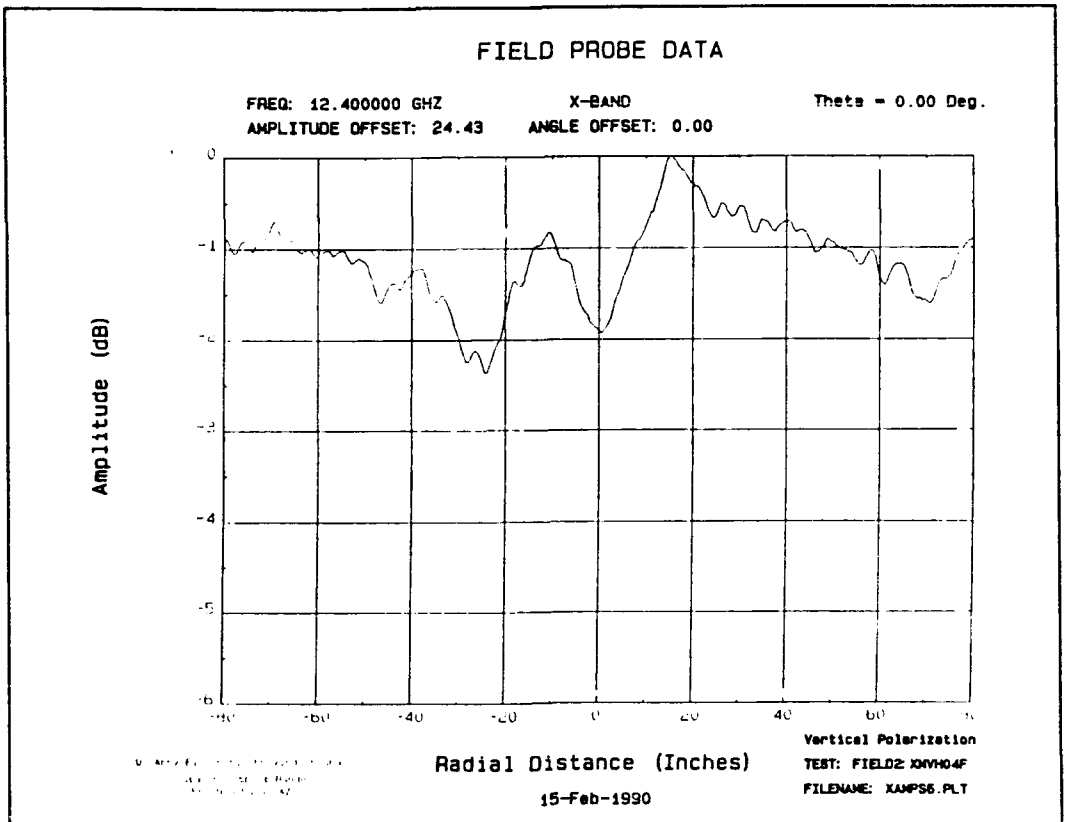

FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -63.81
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 XHVH04E
FILENAME: MARK1U.PLT

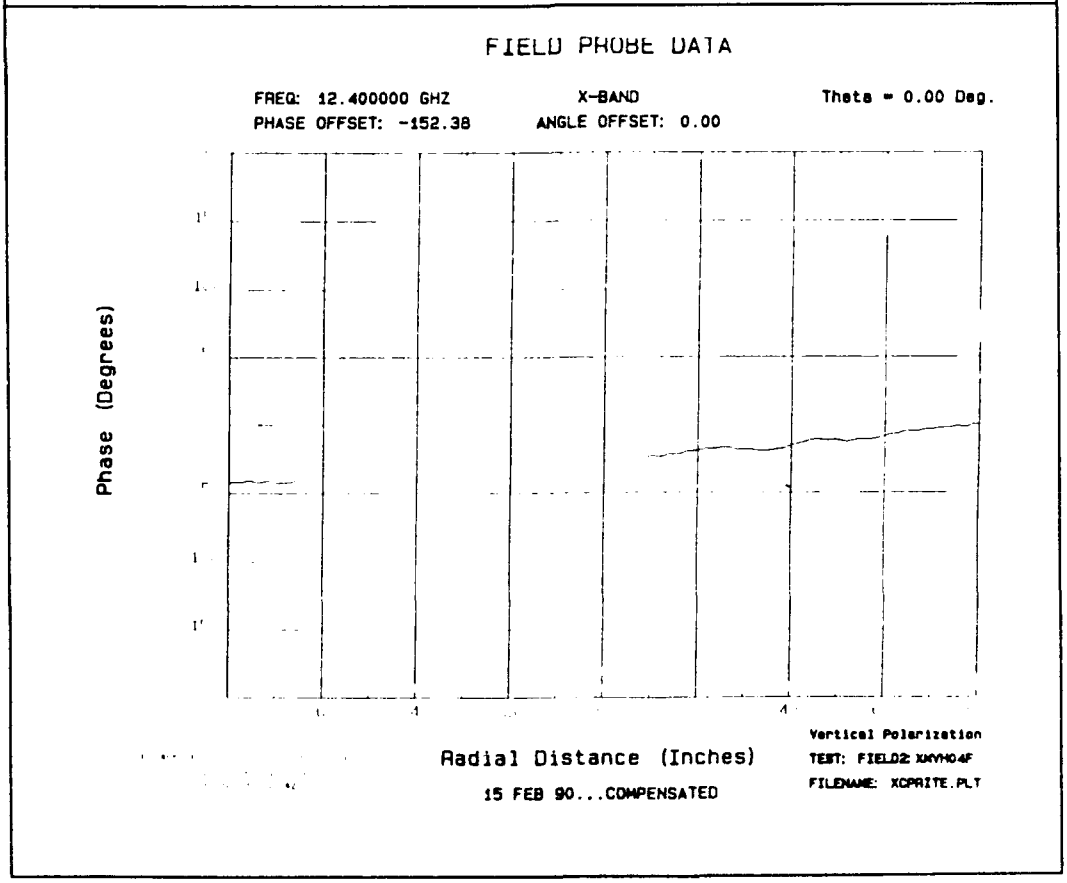


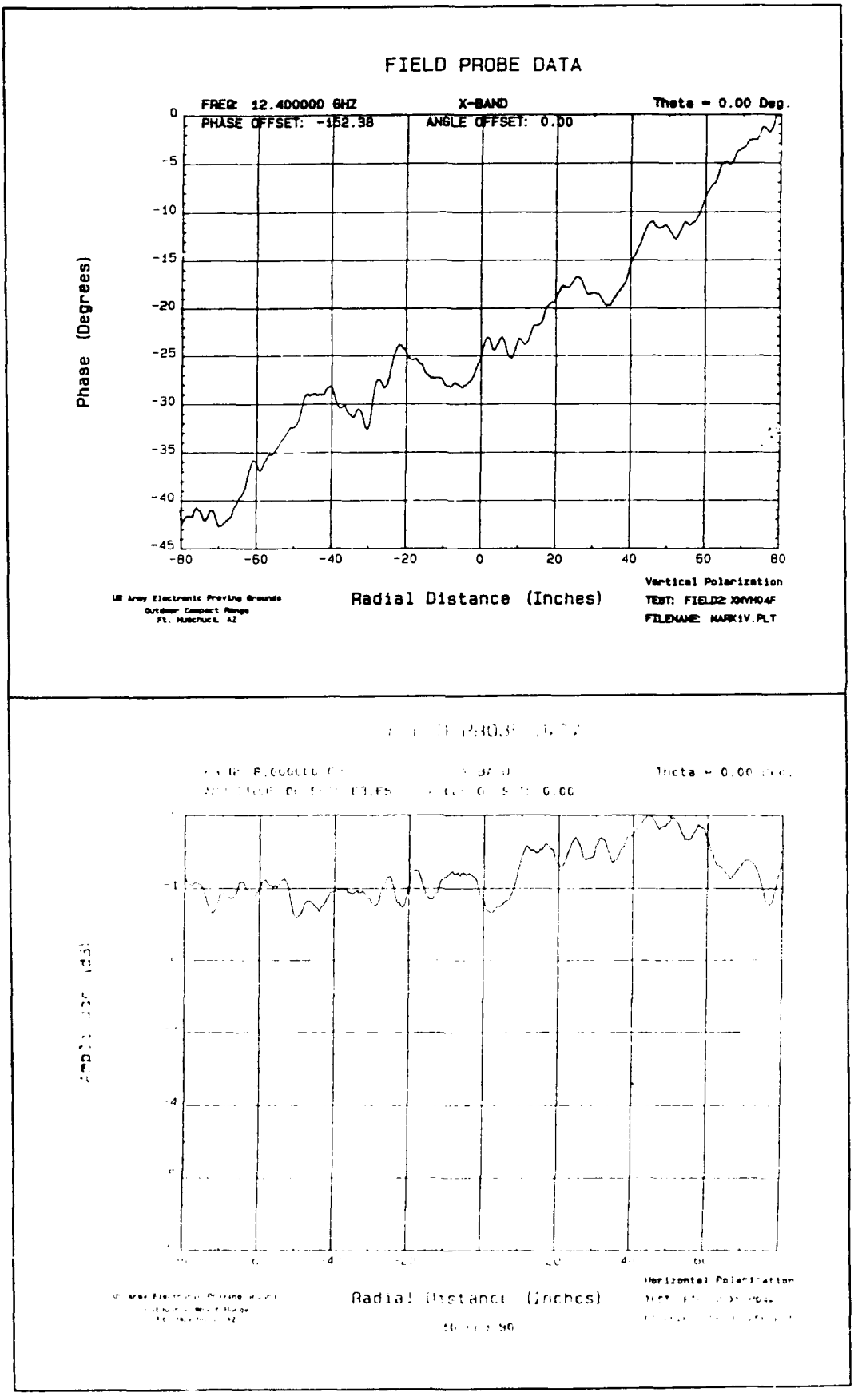
FIELD PROBE DATA

FREQ: 12.400000 GHZ X-BAND Theta = 0.00 Deg.
PHASE OFFSET: -194.84 ANGLE OFFSET: 0.00




FIELD PROBE DATA
FREQ: 12.400000 GHZ
X-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 24.43
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-4
-5
-6
-40
-20
0
20
40
Radial Distance (Inches)
15-Feb-1990
Vertical Polarization
TEST: FIELD2:XMVH04F
FILENAME: XAMPS6.PLT


FIELD PROBE DATA
FREQ: 12.400000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -152.38
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
15 FEB 90...COMPENSATED
Vertical Polarization
TEST: FIELD2:XMVH04F
FILENAME: XCPRITE.PLT


FIELD PROBE DATA
FREQ: 12.400000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -152.38
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2 XMYM04F
FILENAME: MARK1V.PLT

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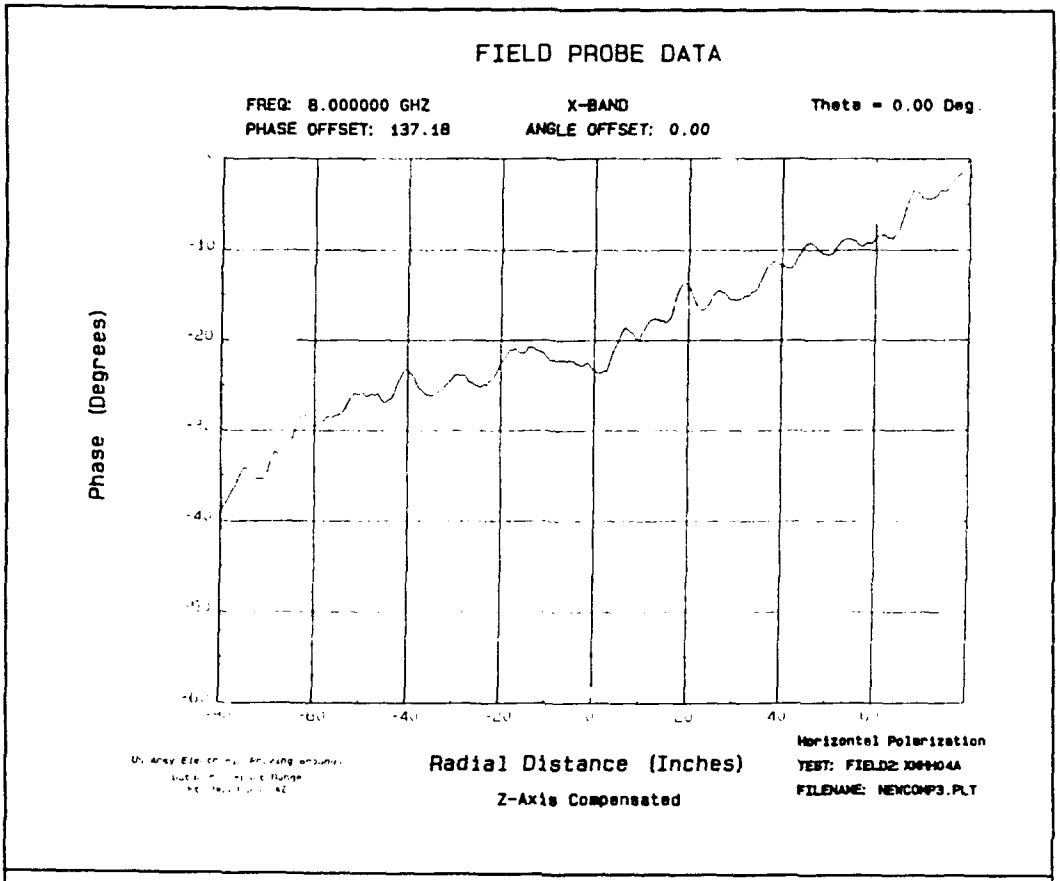
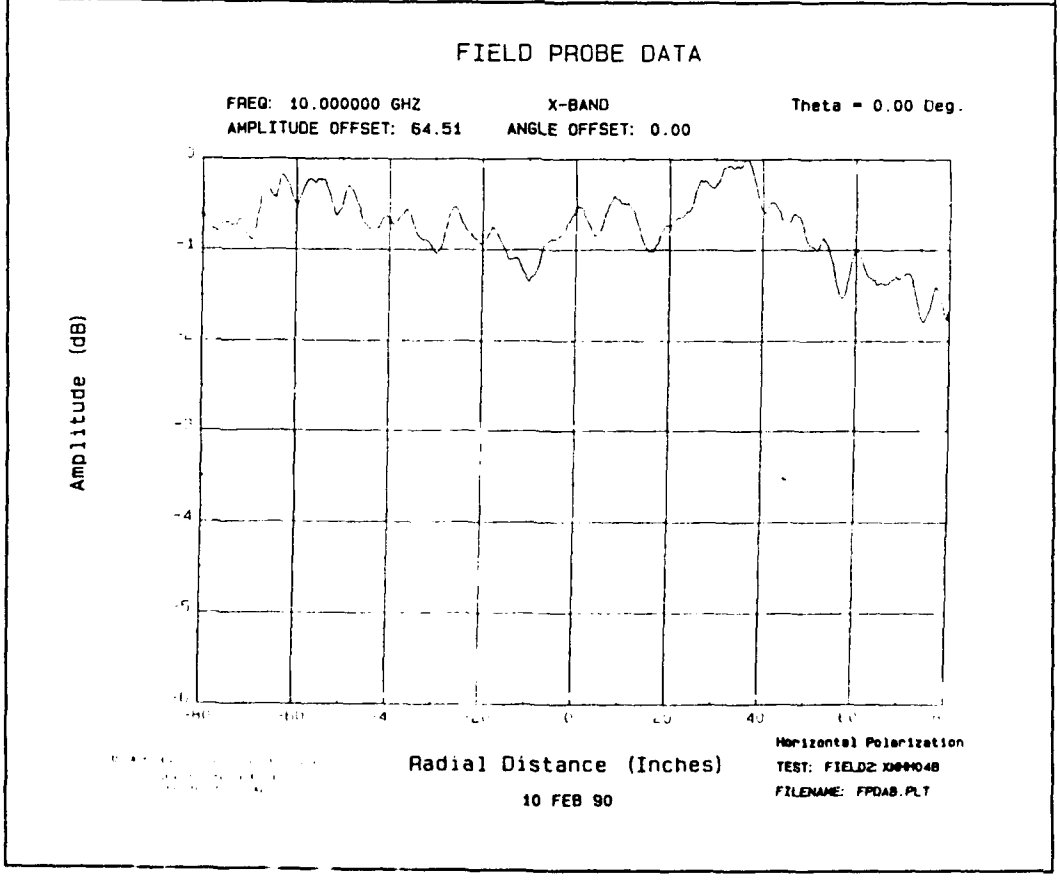
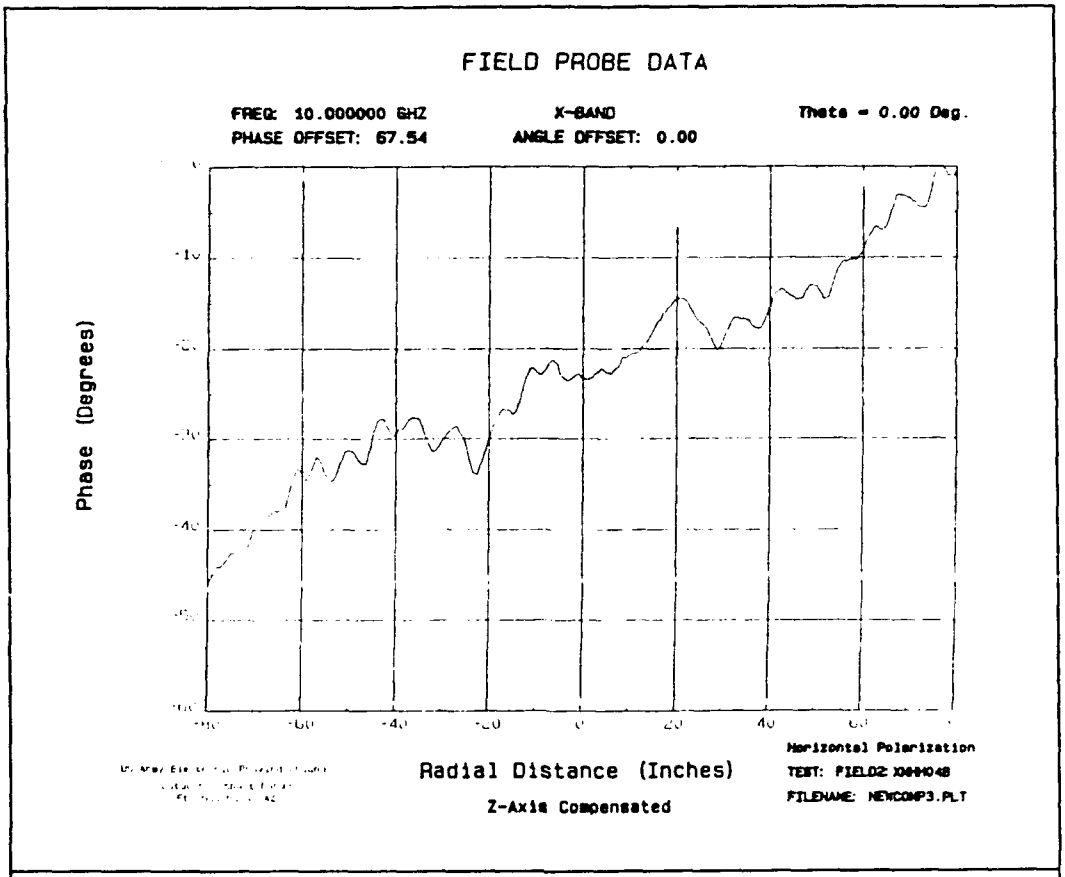
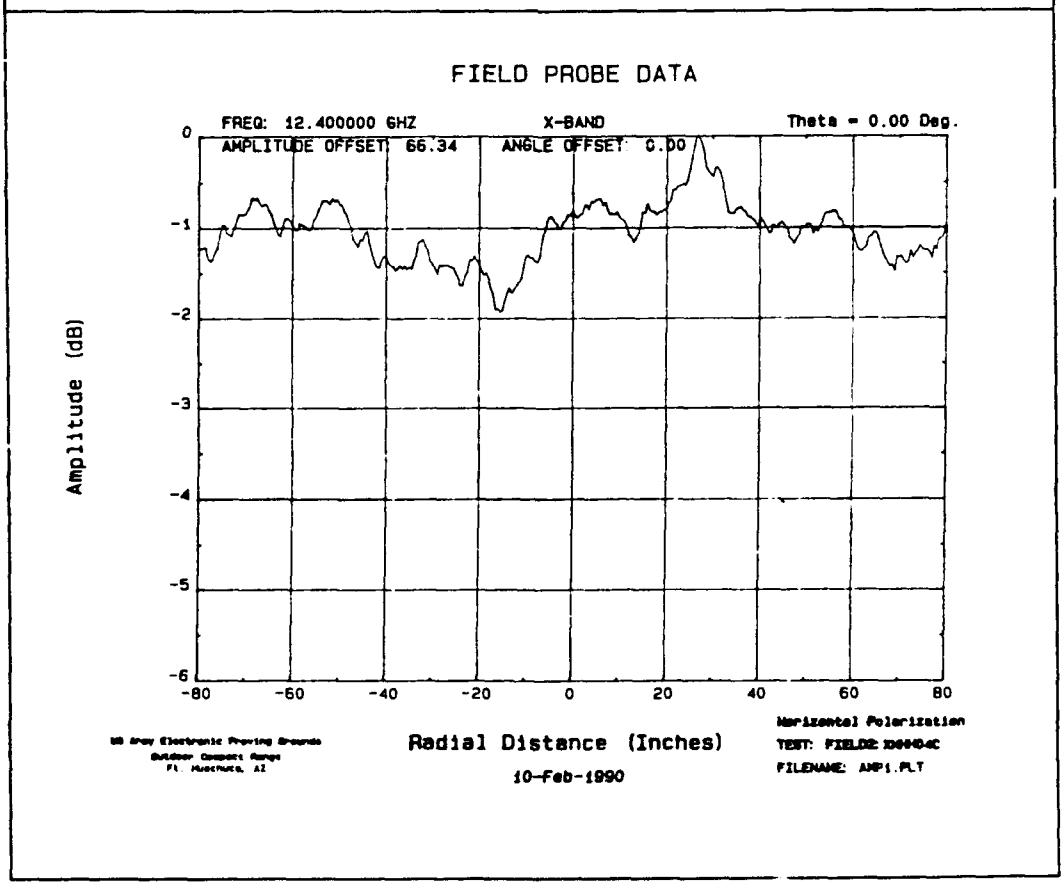
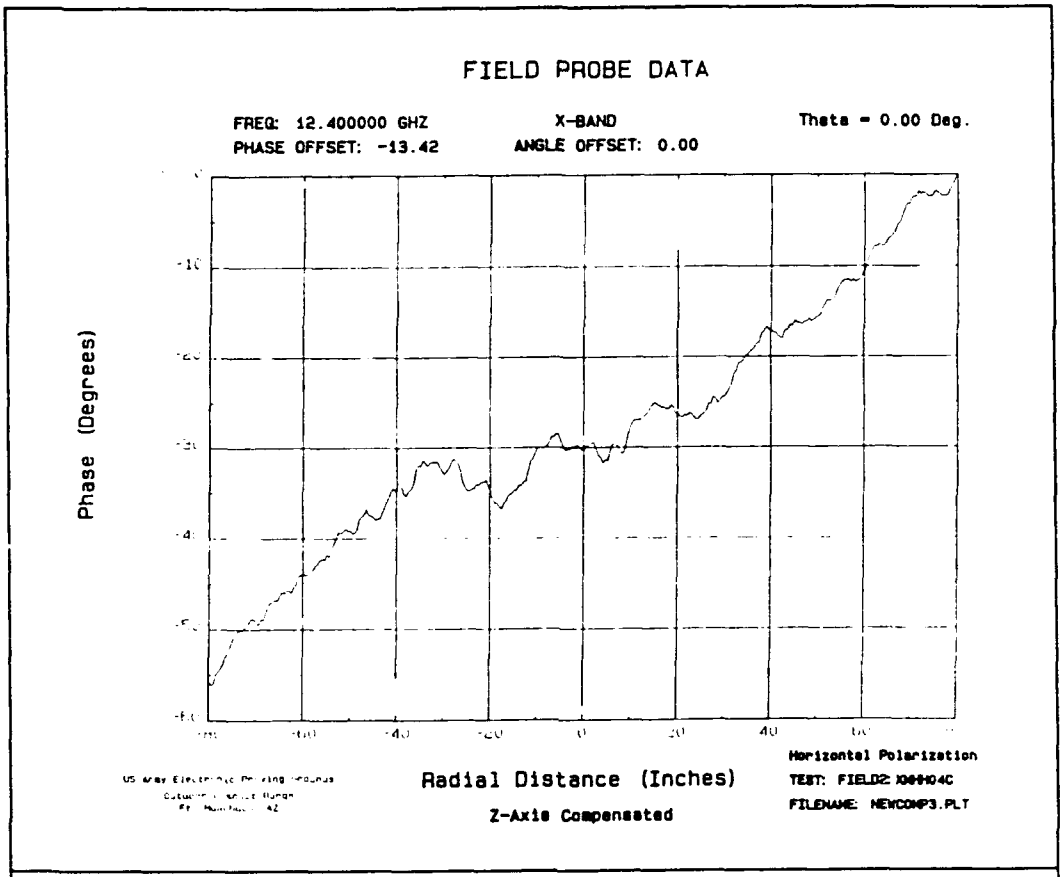
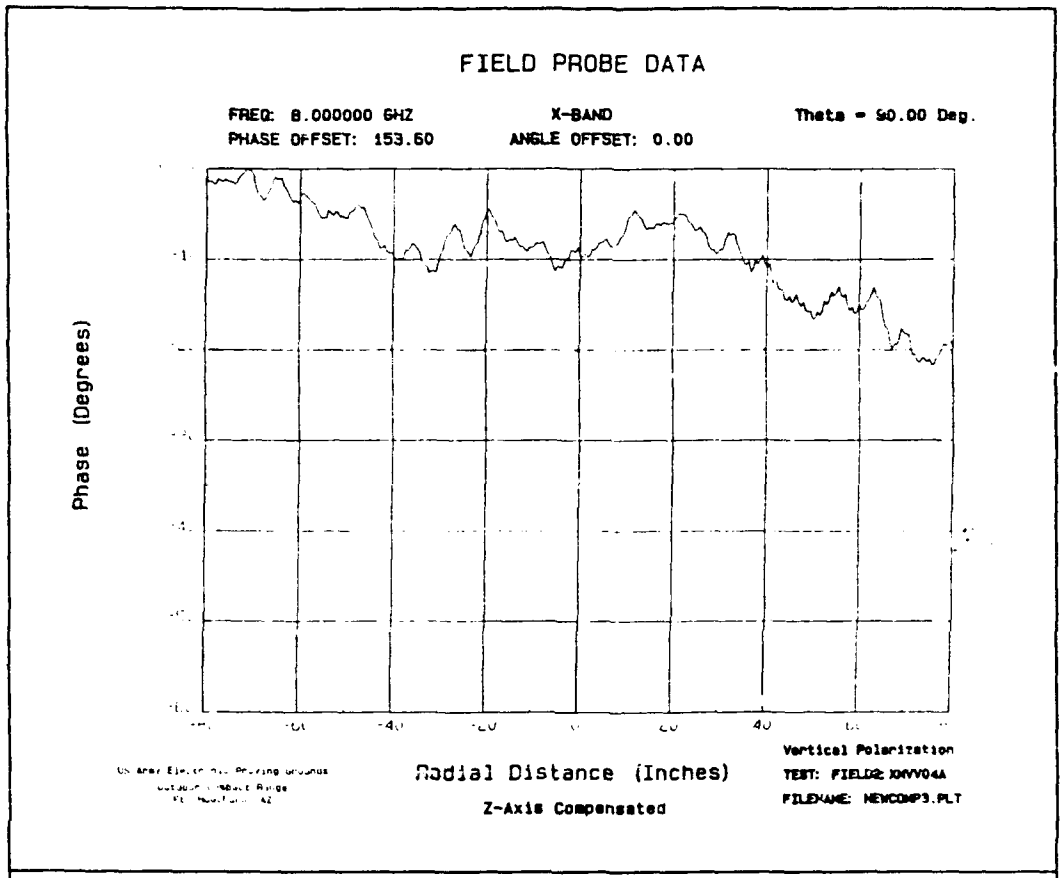

FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 137.18
ANGLE OFFSET: 0.00
Phase (Degrees)
-10
-20
-40
-60
-40
-20
0
20
40
60
Radial Distance (Inches)
Z-Axis Compensated
Horizontal Polarization
TEST: FIELD2 X0000104A
FILENAME: NEWCOMP3.PLT

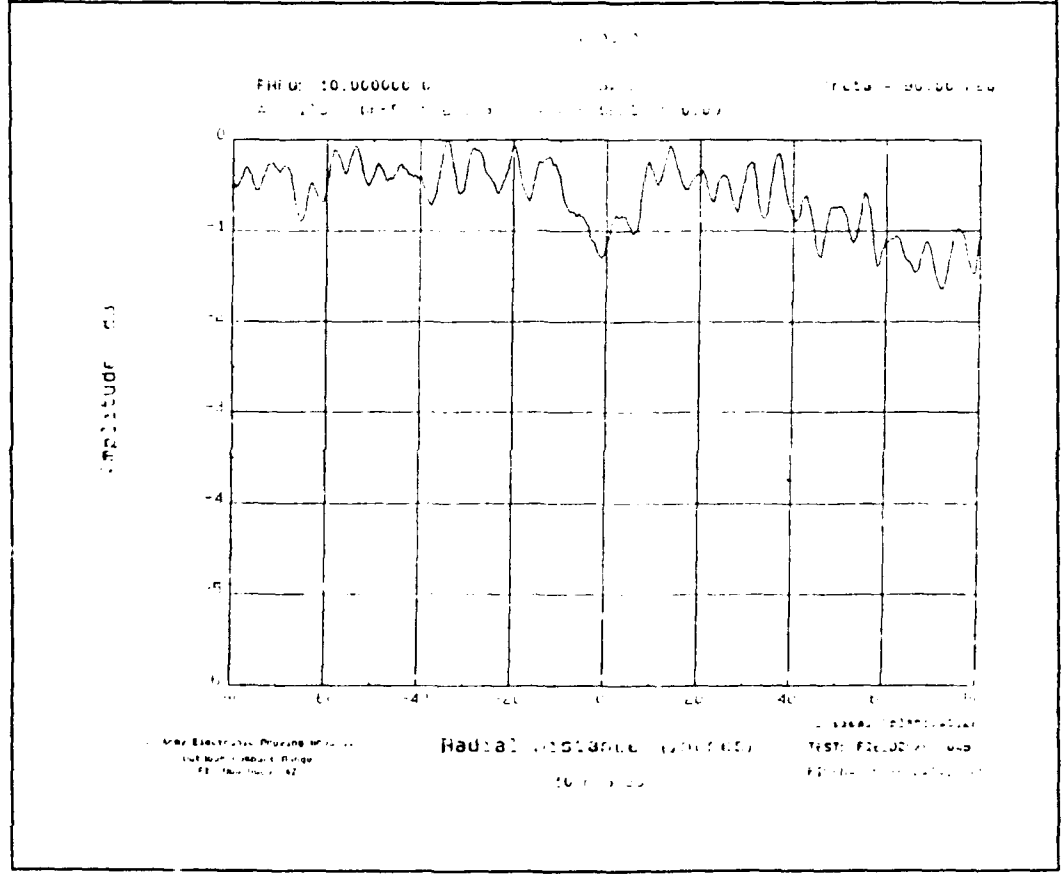

FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 64.51
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-4
-5
-40
-20
0
20
40
60
Radial Distance (Inches)
10 FEB 90
Horizontal Polarization
TEST: FIELD2 X0000104B
FILENAME: FPDAB.PLT

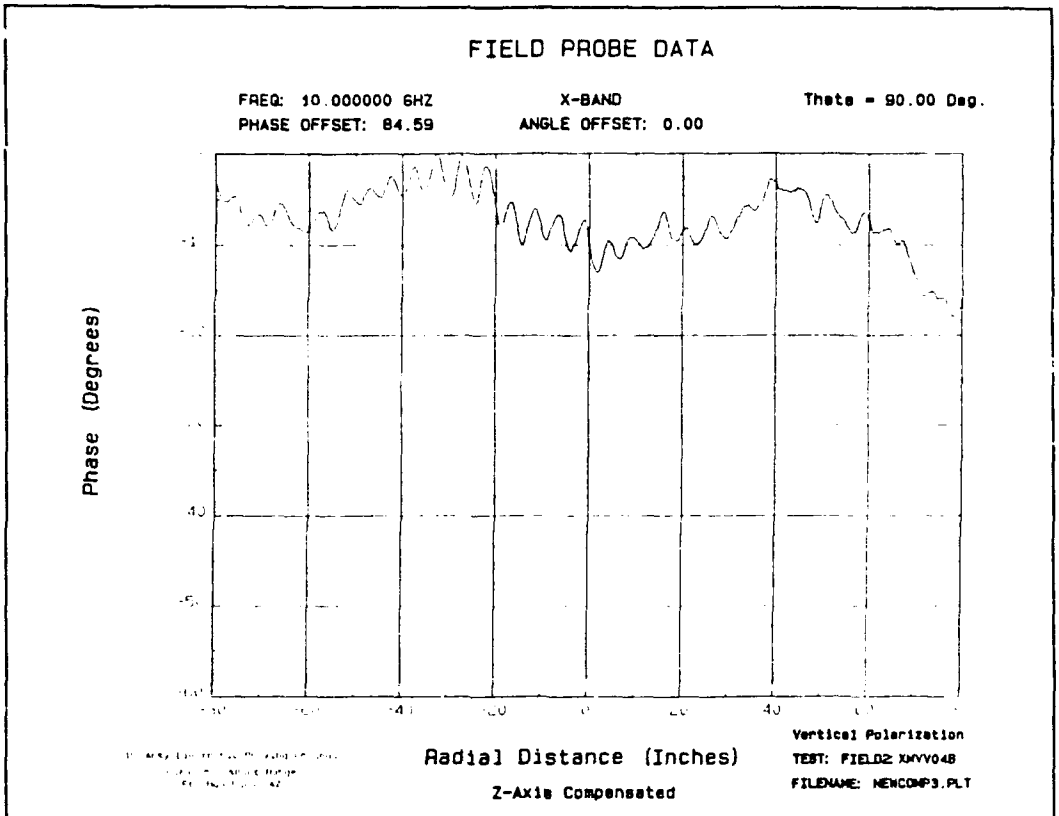

FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 67.54
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
Z-Axis Compensated
Horizontal Polarization
TEST: FIELD2 XXHH04B
FILENAME: NEWCOMP3.PLT

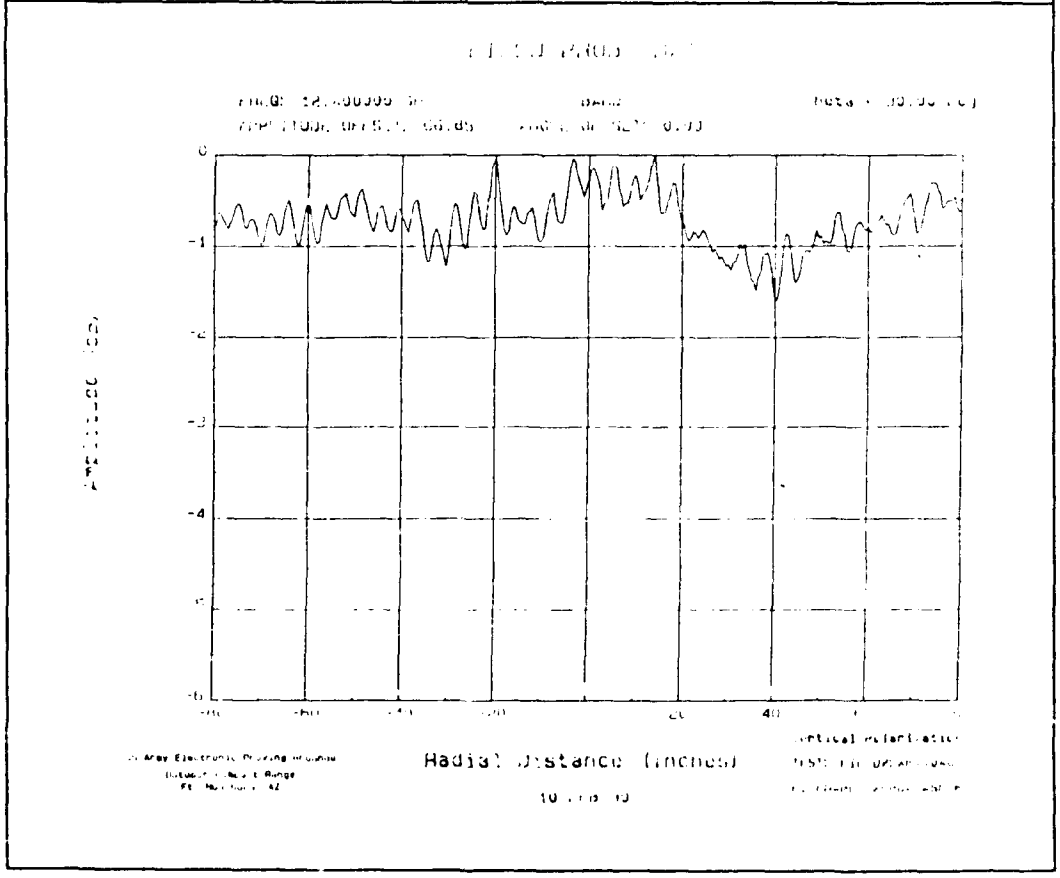

FIELD PROBE DATA
FREQ: 12.400000 GHZ
X-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 66.34
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
10-Feb-1990
Horizontal Polarization
TEST: FIELD2 XXHH04C
FILENAME: AMP1.PLT

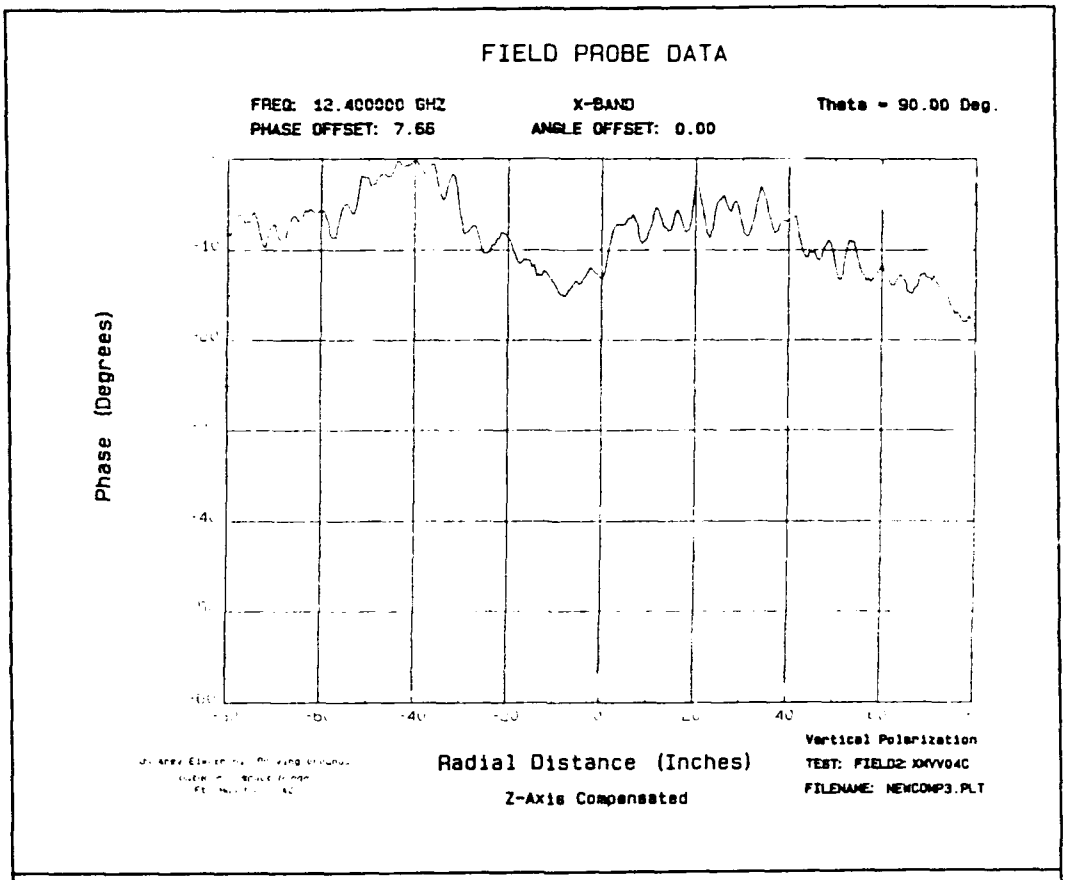

FIELD PROBE DATA
FREQ: 12.400000 GHZ
X-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -13.42
ANGLE OFFSET: 0.00
Phase (Degrees)
-10
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
-320
-340
-360
-380
-400
-420
-440
-460
-480
-500
-520
-540
-560
-580
-600
-620
-640
-660
-680
-700
-720
-740
-760
-780
-800

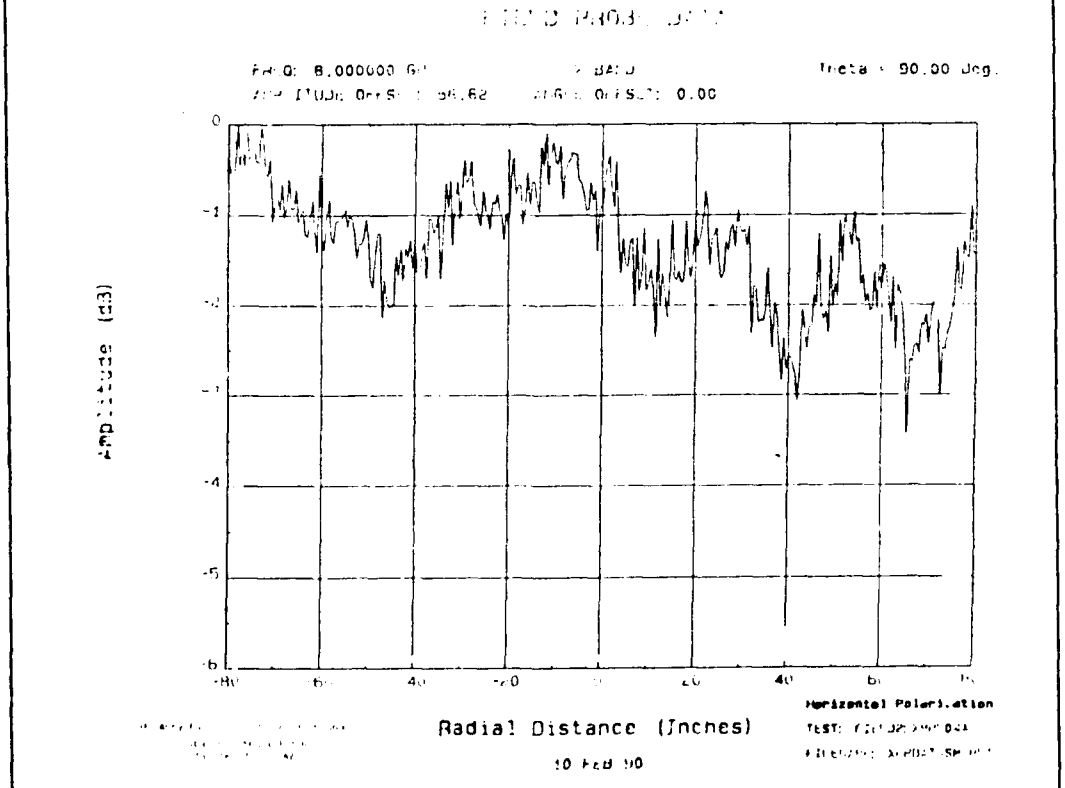

FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 153.60
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
Z-Axis Compensated
Vertical Polarization
TEST: FIELD2 XHVV04A
FILENAME: NEWCOMP3.PLT

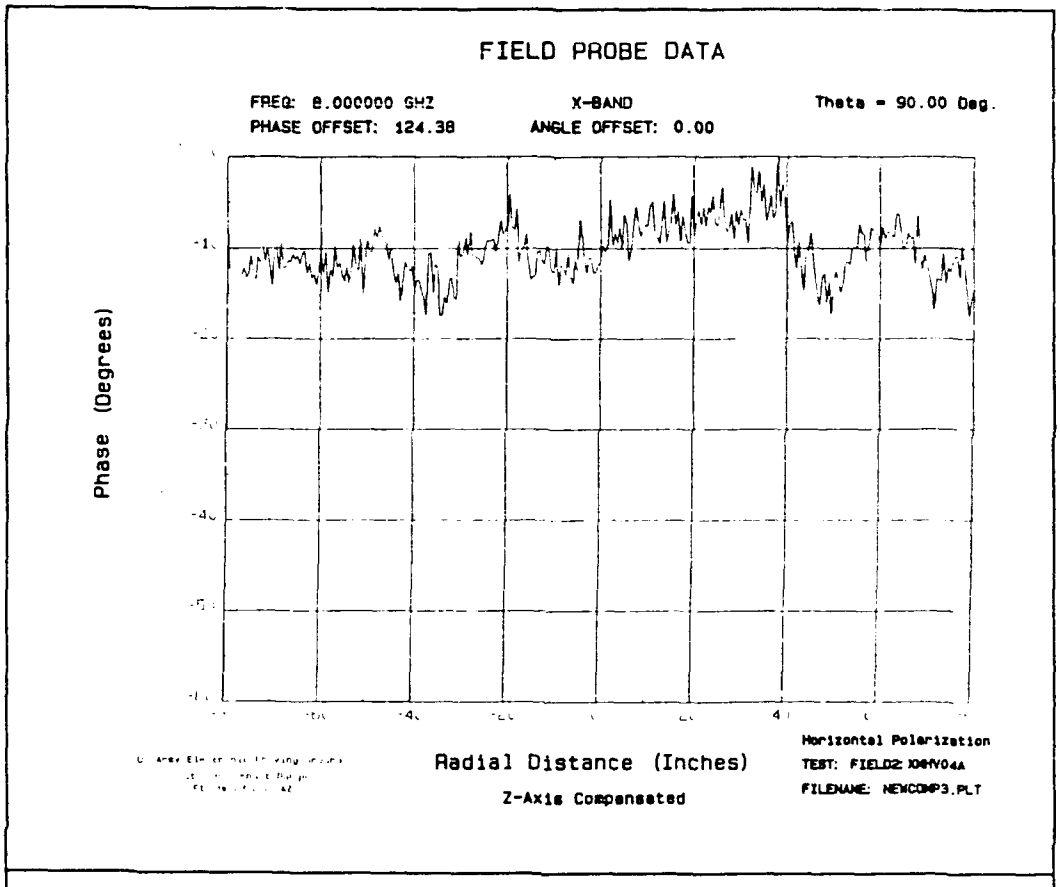


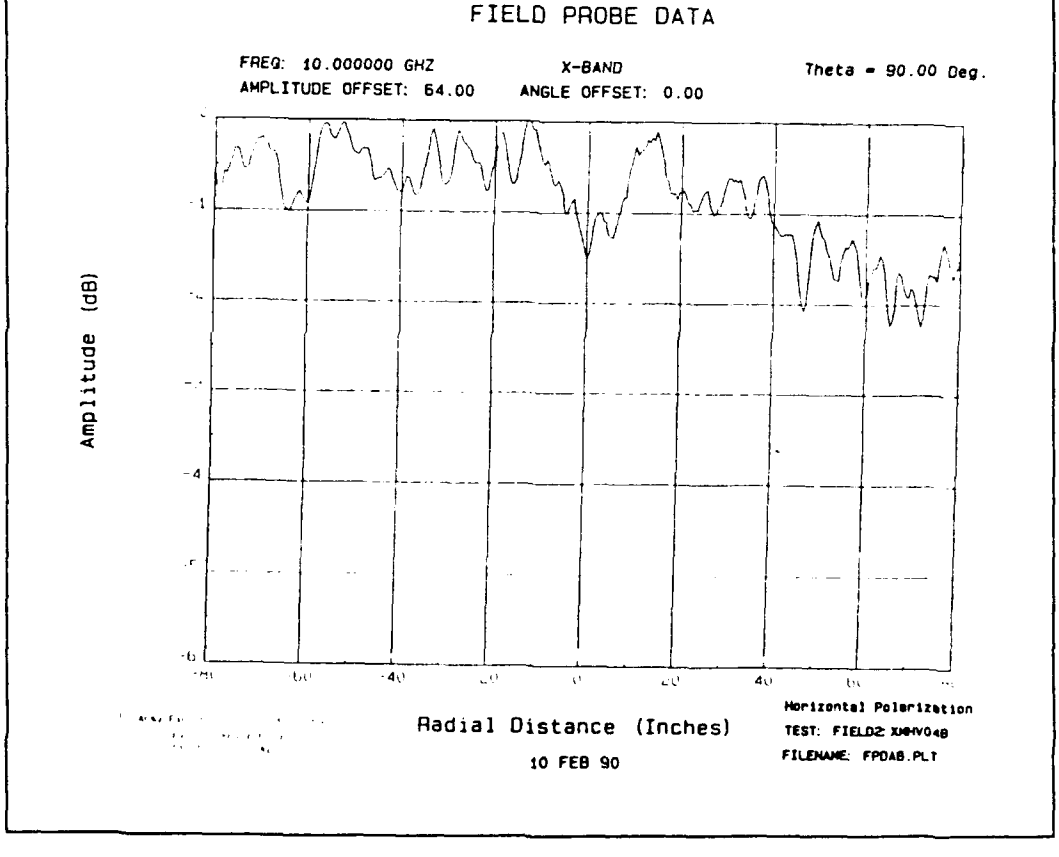

FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 84.59
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
Z-Axis Compensated
Vertical Polarization
TEST: FIELD2 XMVV048
FILENAME: NEWCOMP3.PLT

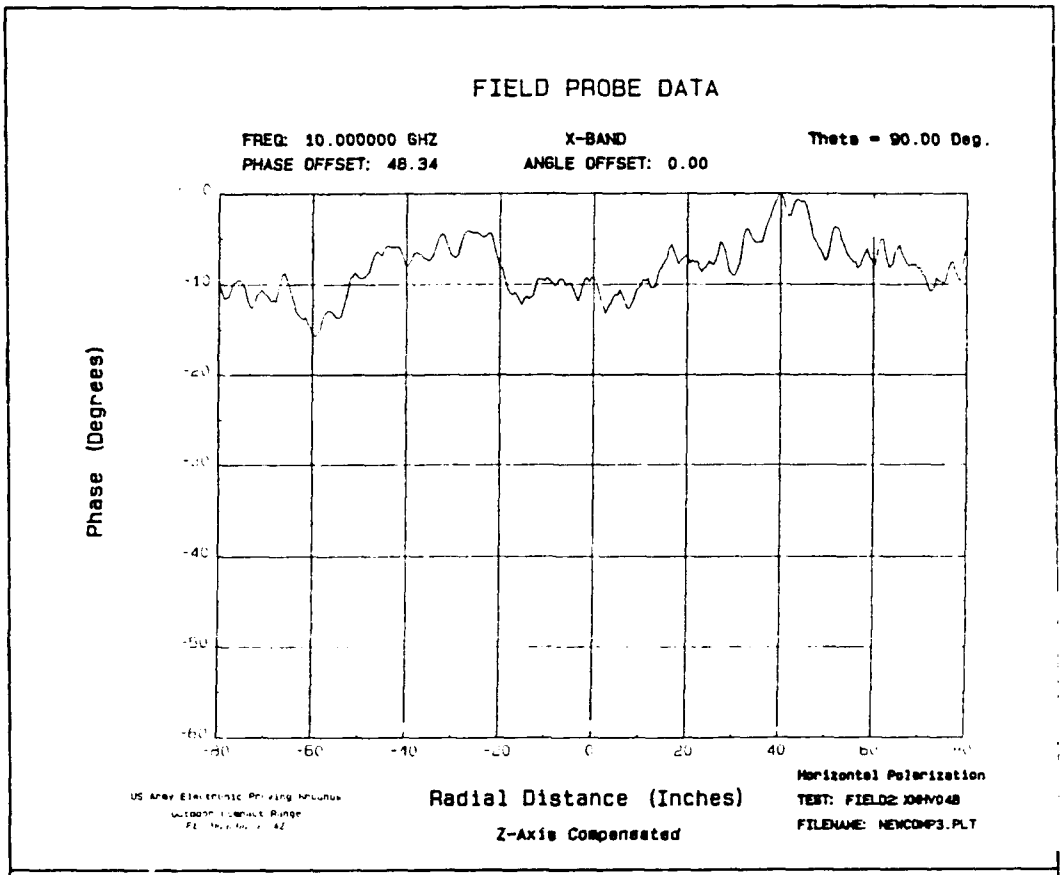


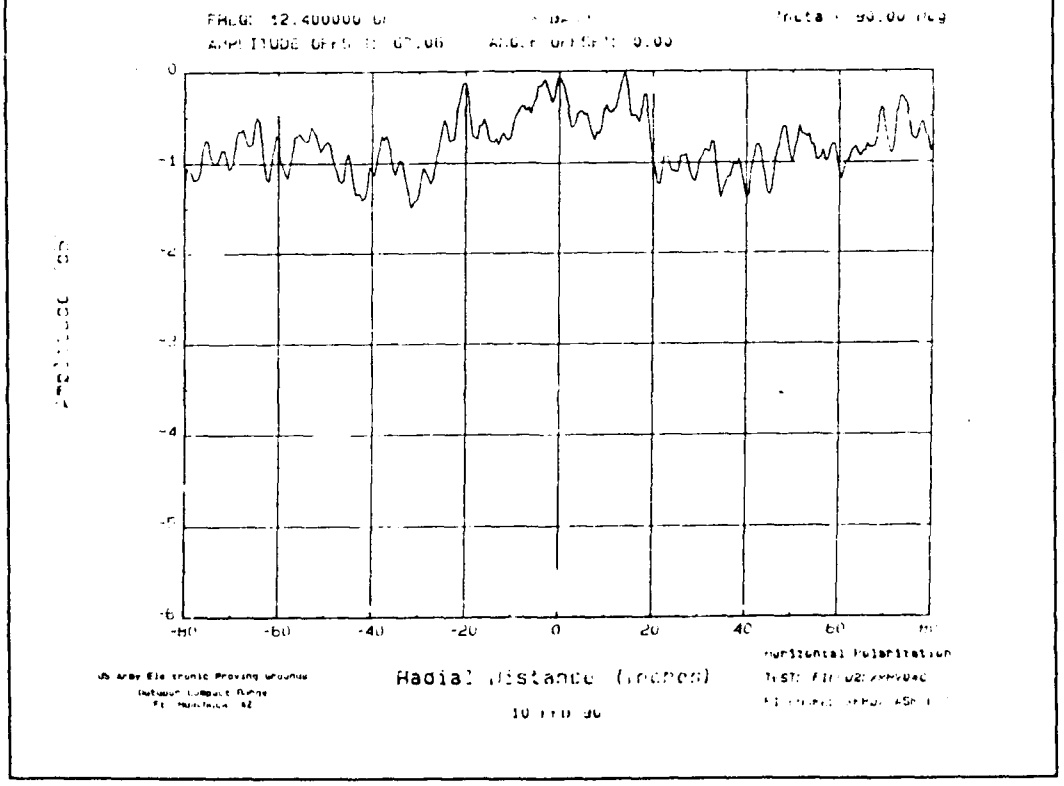

FIELD PROBE DATA
FREQ: 12.400000 GHZ
X-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 7.66
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
Z-Axis Compensated
Vertical Polarization
TEST: FIELD2 XHVV04C
FILENAME: NEWCOMP3.PLT

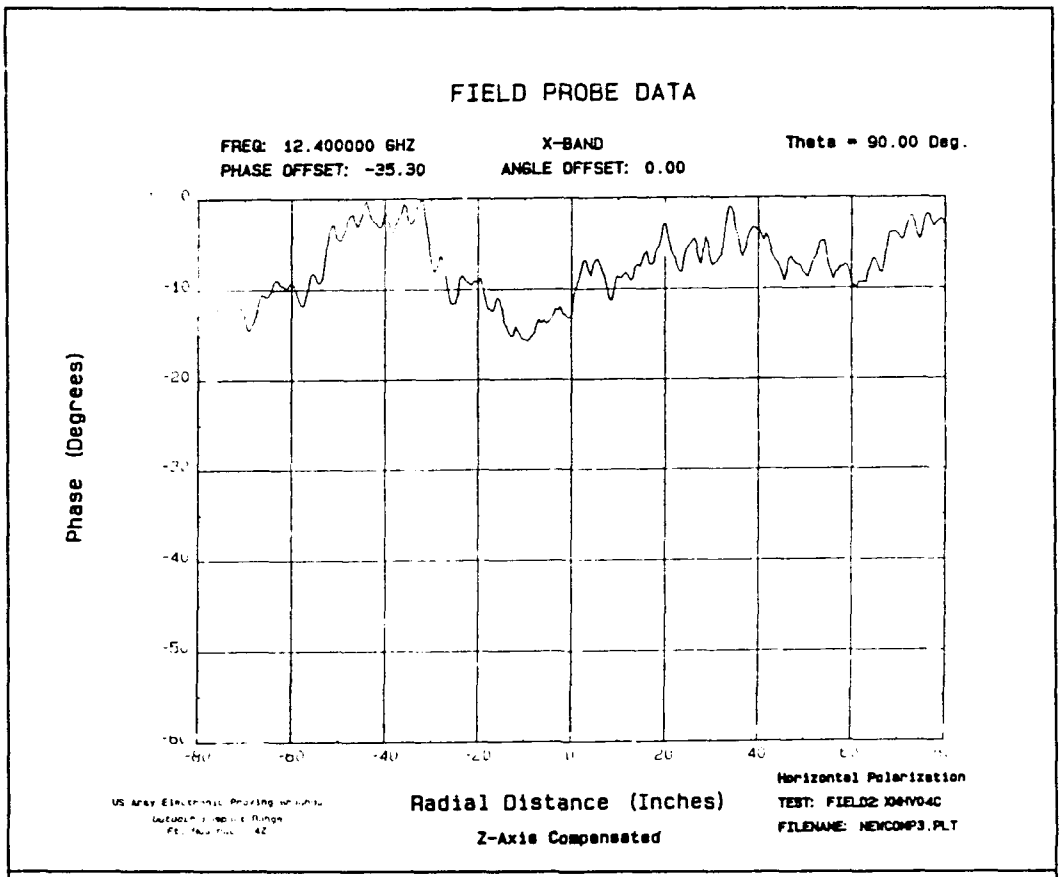

Theta = 90.00 Deg.
ANGLE OFFSET: 0.00
Radial Distance (Inches)
Horizontal Polarization

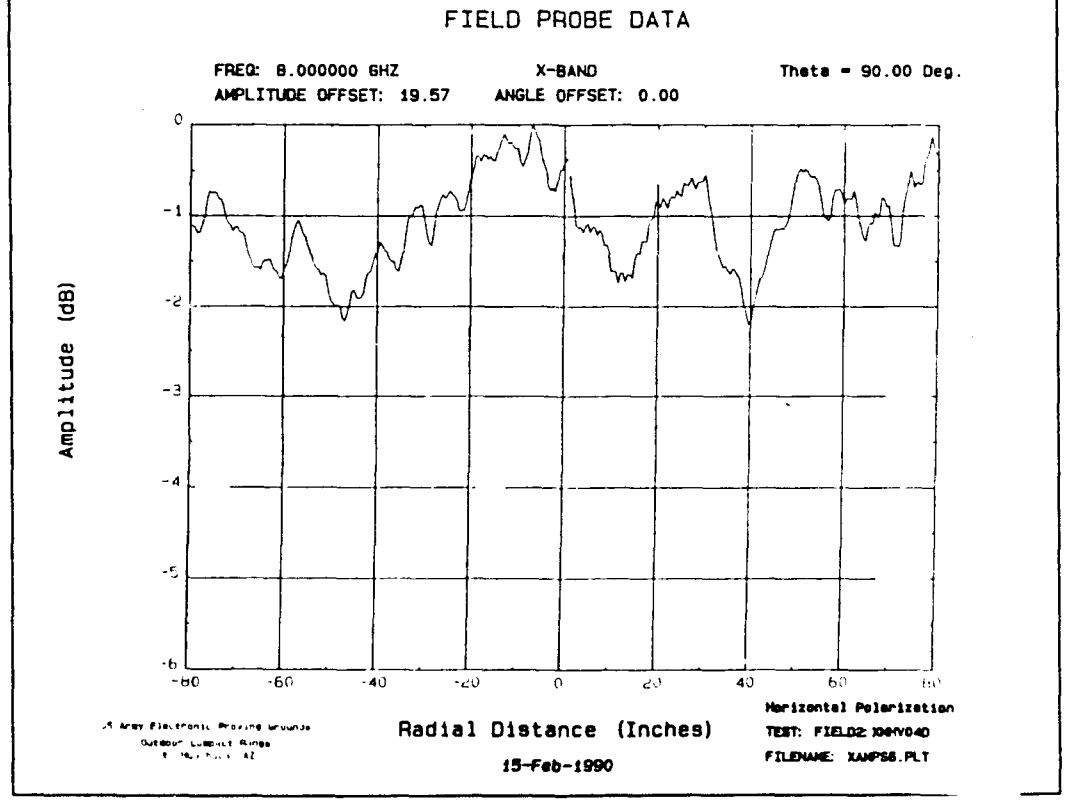

FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 124.38
ANGLE OFFSET: 0.00
Phase (Degrees)
Radial Distance (Inches)
Z-Axis Compensated
Horizontal Polarization
TEST: FIELD2 X04V04A
FILENAME: NEWCOMP3.PLT

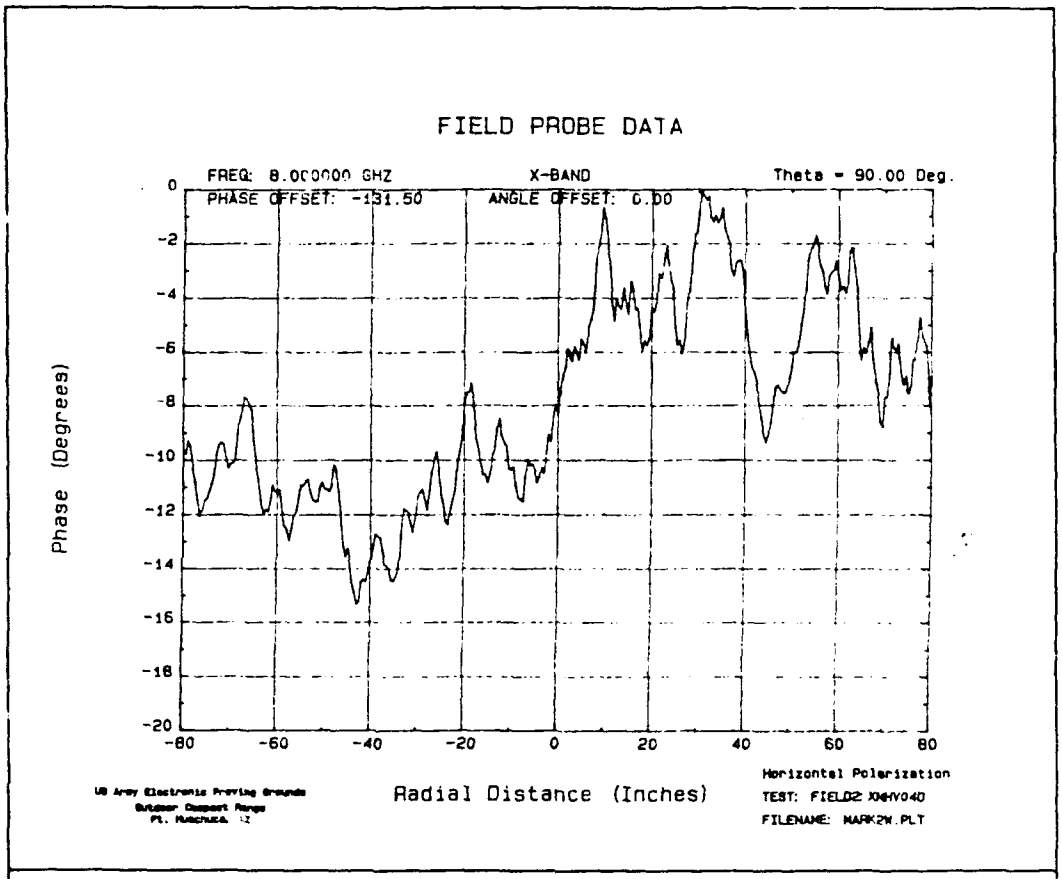

FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 64.00
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
10 FEB 90
Horizontal Polarization
TEST: FIELD2 X04V04B
FILENAME: FPDAB.PLT

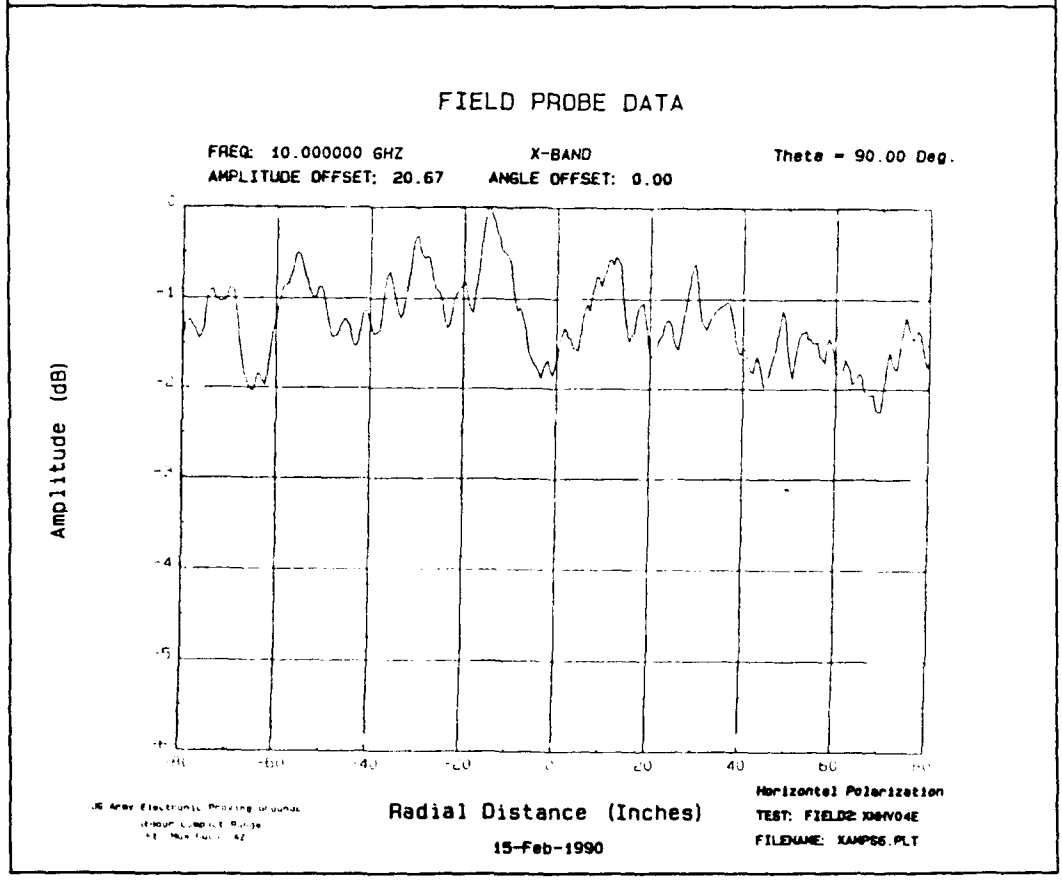

FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 48.34
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-80
-60
-40
-20
0
20
40
60
US Army Electronic Proving Grounds
Radial Distance (Inches)
Z-Axis Compensated
Horizontal Polarization
TEST: FIELD2 X04V04B
FILENAME: NEWCOMP3.PLT

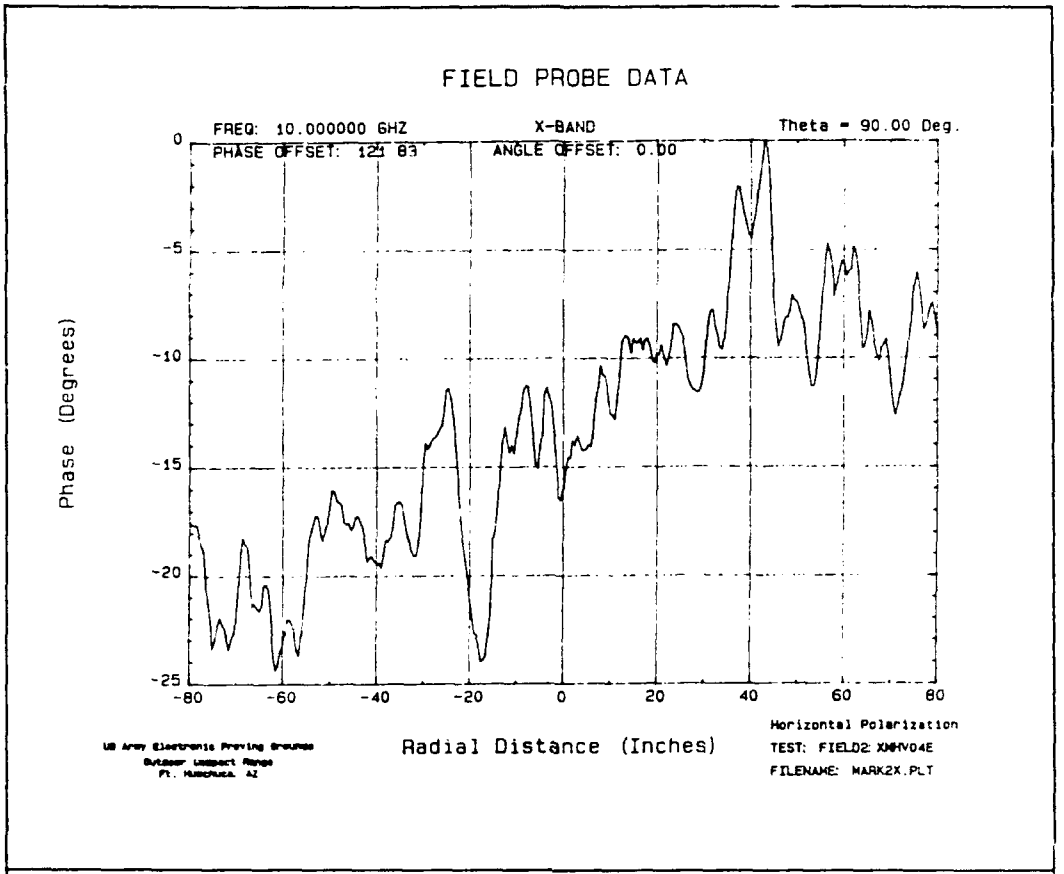

0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60

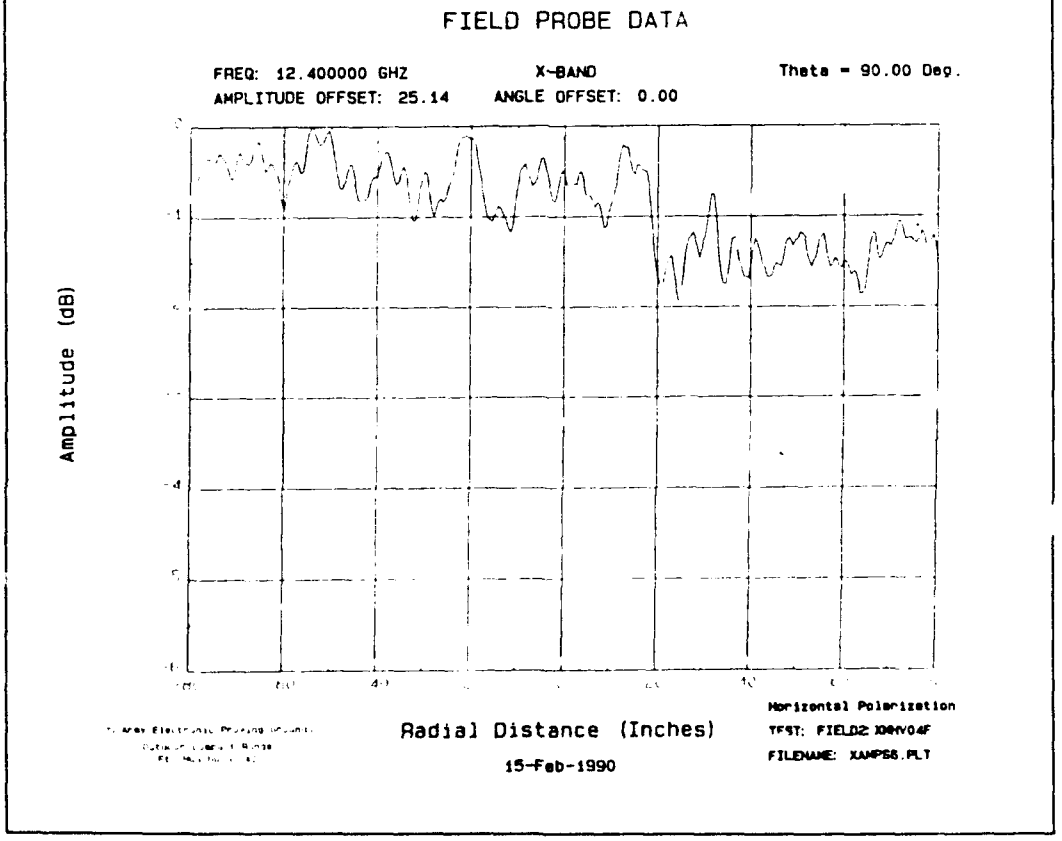

FIELD PROBE DATA
FREQ: 12.400000 GHZ
X-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -35.30
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-40
-50
-60
-80
-60
-40
-20
0
20
40
Radial Distance (Inches)
Z-Axis Compensated
Horizontal Polarization
TEST: FIELD2 X04V04C
FILENAME: NEWCOMP3.PLT

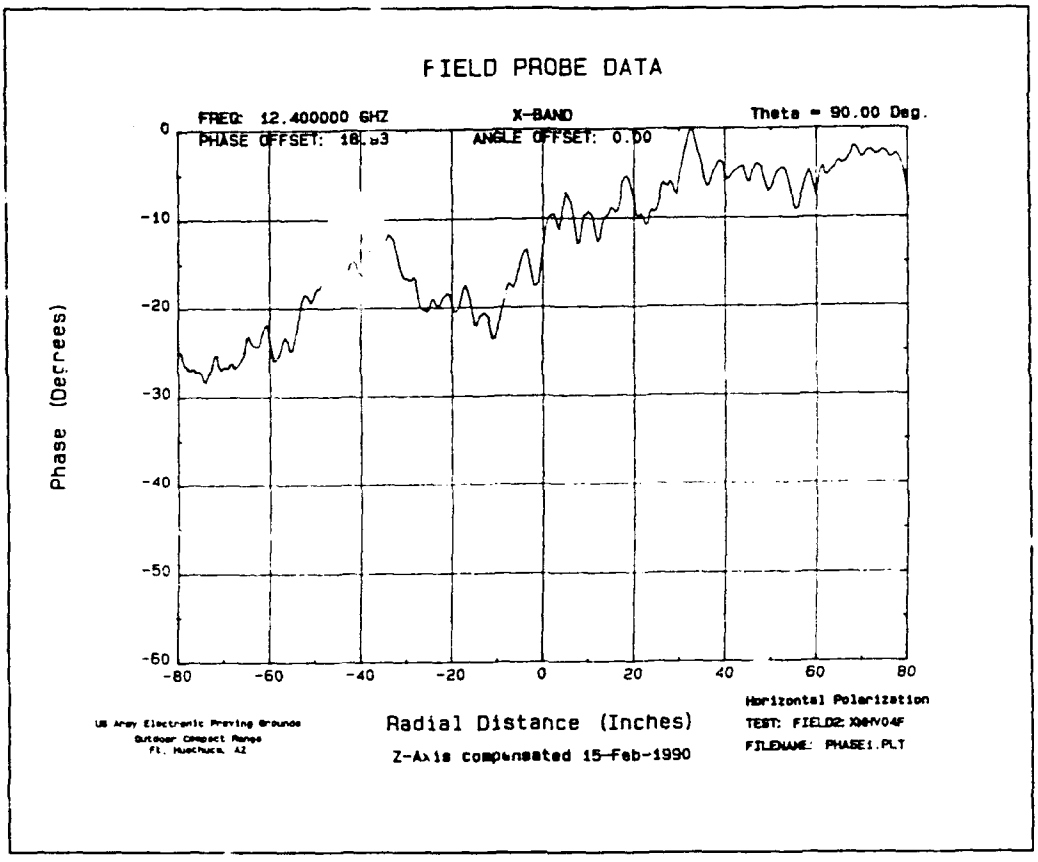

FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 19.57
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
15-Feb-1990
Horizontal Polarization
TEST: FIELD2 X04V04D
FILENAME: XAMPS6.PLT

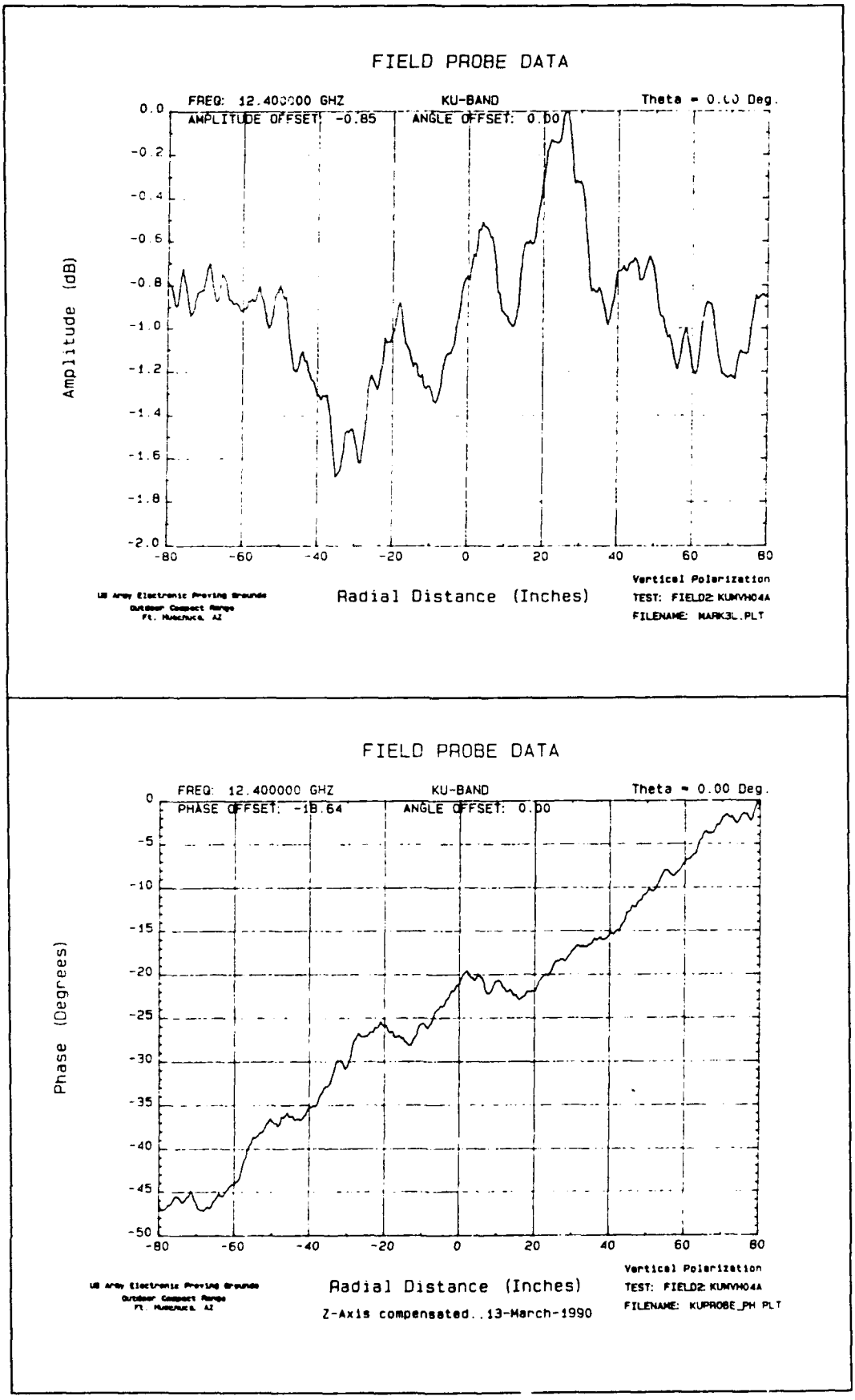

FIELD PROBE DATA
FREQ: 8.000000 GHZ
X-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -131.50
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 X06V040
FILENAME: MARK2W.PLT

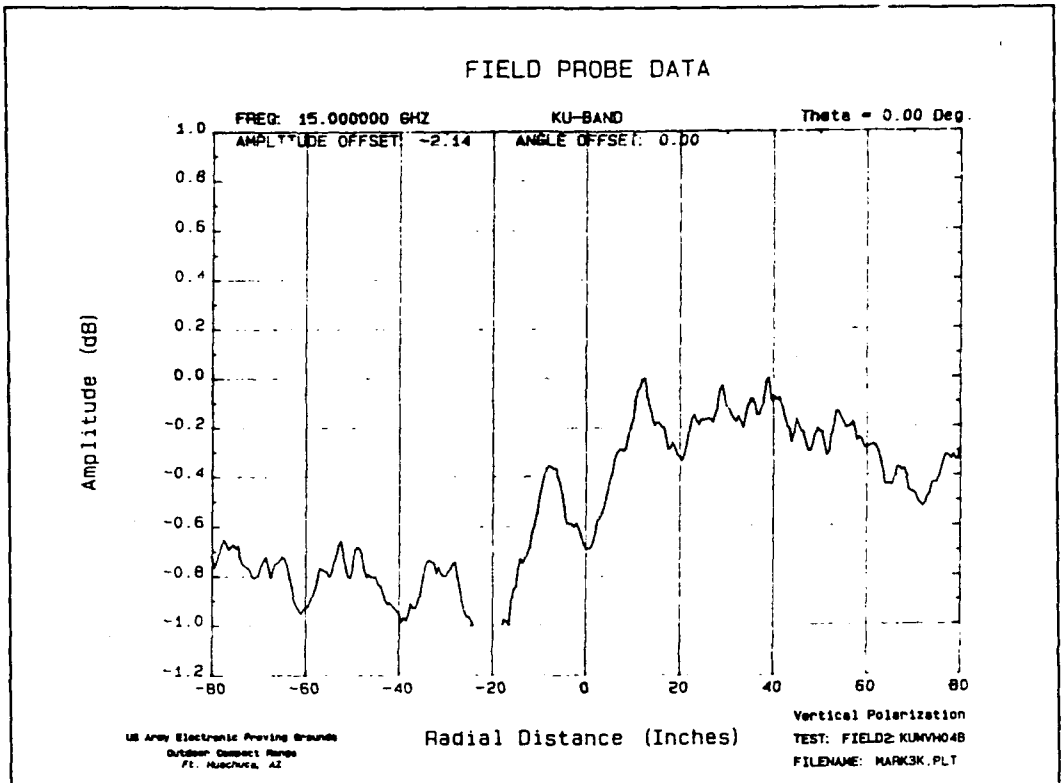

FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 20.67
ANGLE OFFSET: 0.00
Amplitude (dB)
-1
-4
-5
Radial Distance (Inches)
15-Feb-1990
Horizontal Polarization
TEST: FIELD2 X06V04E
FILENAME: XAMP56.PLT

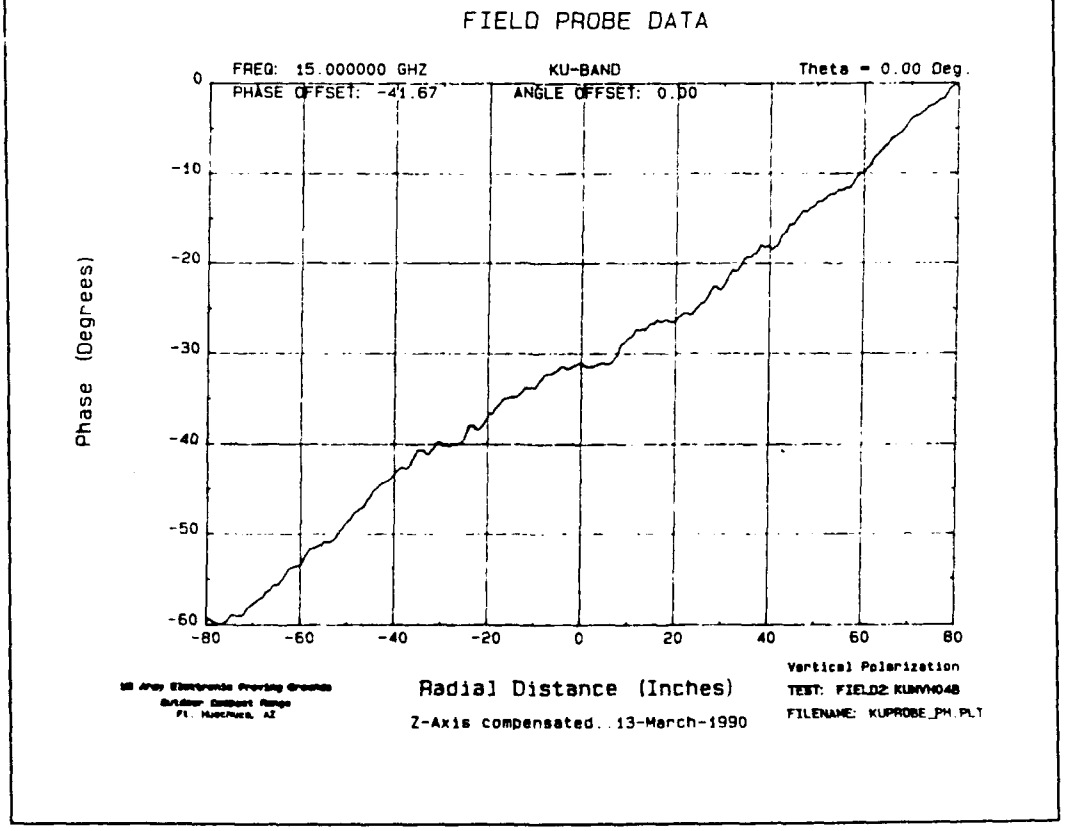

FIELD PROBE DATA
FREQ: 10.000000 GHZ
X-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 121.83
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 XBHV04E
FILENAME: MARK2X.PLT

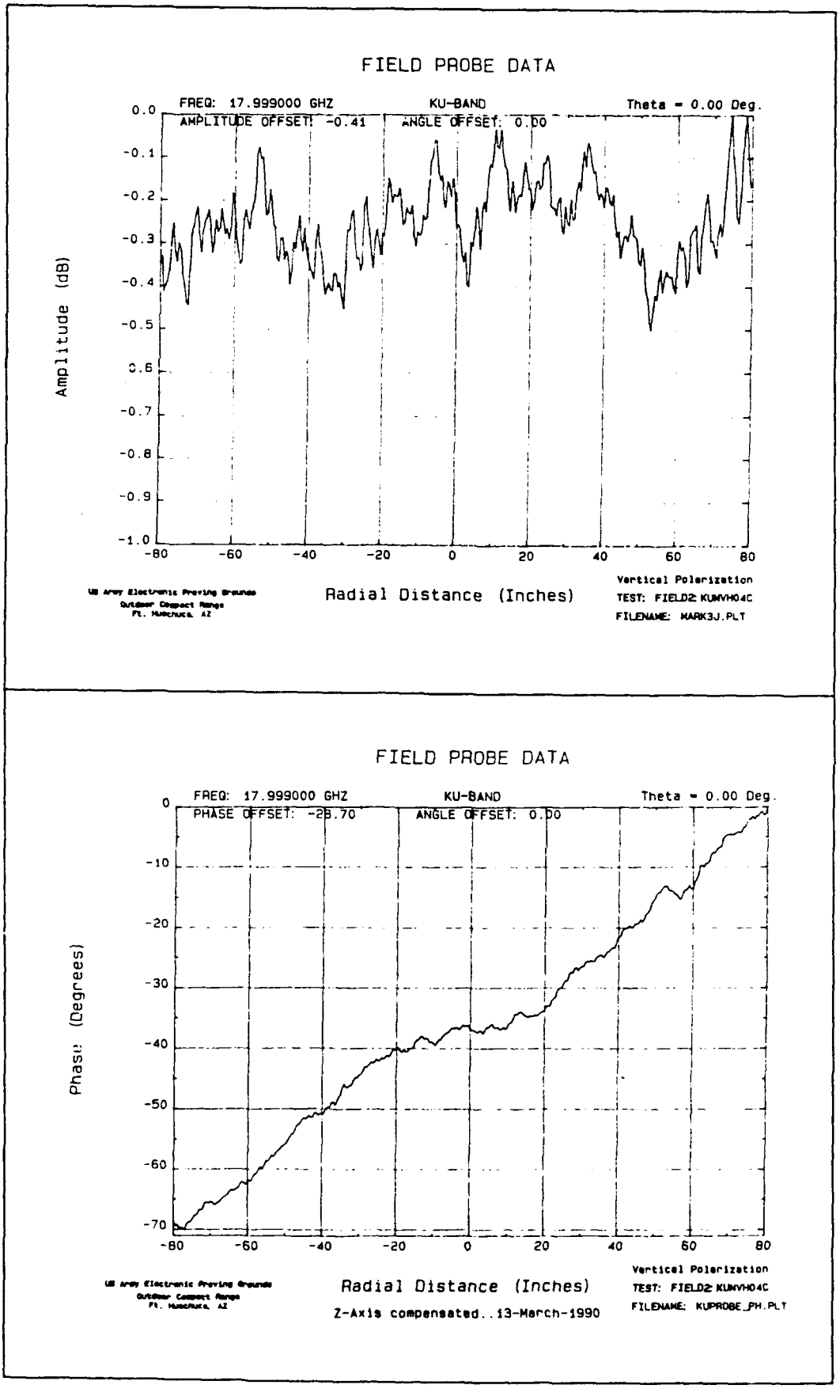

FIELD PROBE DATA
FREQ: 12.400000 GHZ
X-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 25.14
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 XBHV04F
FILENAME: XAMPS6.PLT
15-Feb-1990

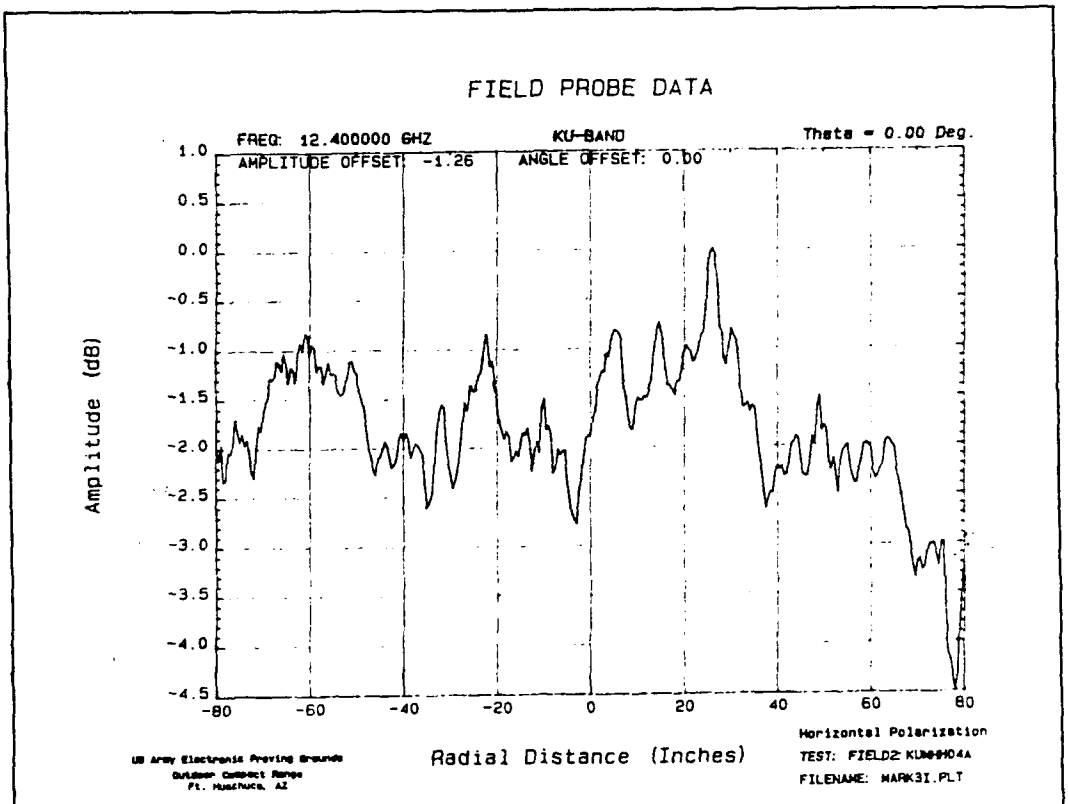

FIELD PROBE DATA
FREQ: 12.400000 GHZ
X-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 18.93
ANGLE OFFSET: 0.00
0
-10
-20
-30
-40
-50
-60
Phase (Degrees)
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 X4HV04F
FILENAME: PHASE1.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Z-Axis compensated 15-Feb-1990

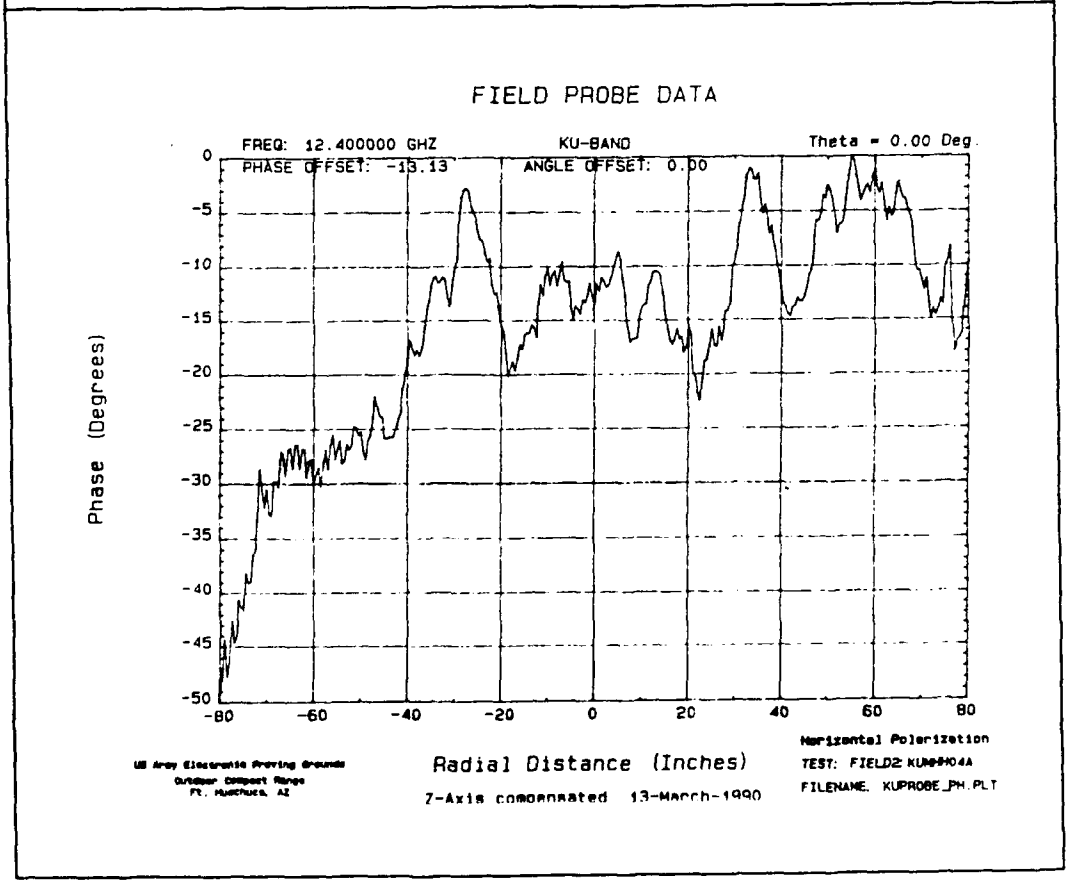

FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: -0.85
ANGLE OFFSET: 0.00
Amplitude (dB)
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2: KUMVH04A
FILENAME: MARK3L.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -18.64
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
Vertical Polarization
TEST: FIELD2: KUMVH04A
FILENAME: KUPROBE_PH PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ

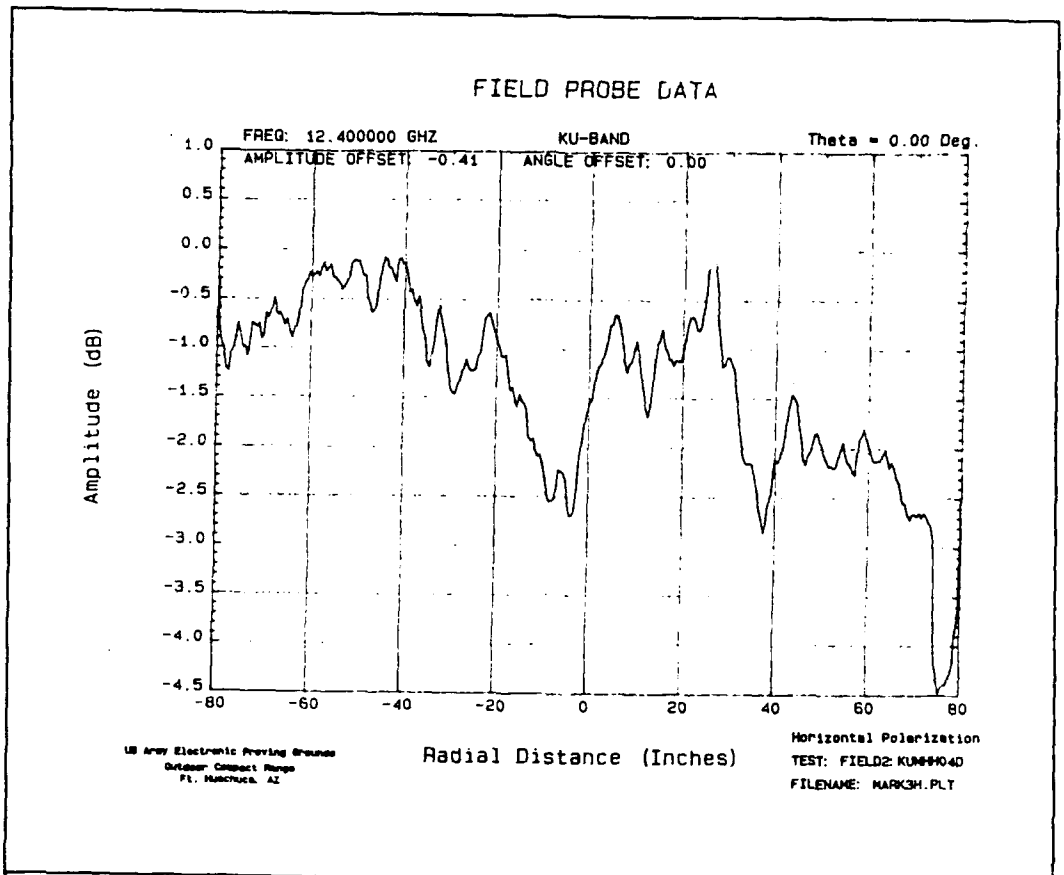

FIELD PROBE DATA
FREQ: 15.000000 GHZ
KU-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: -2.14
ANGLE OFFSET: 0.00
Amplitude (dB)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KUMVH04B
FILENAME: MARK3K.PLT

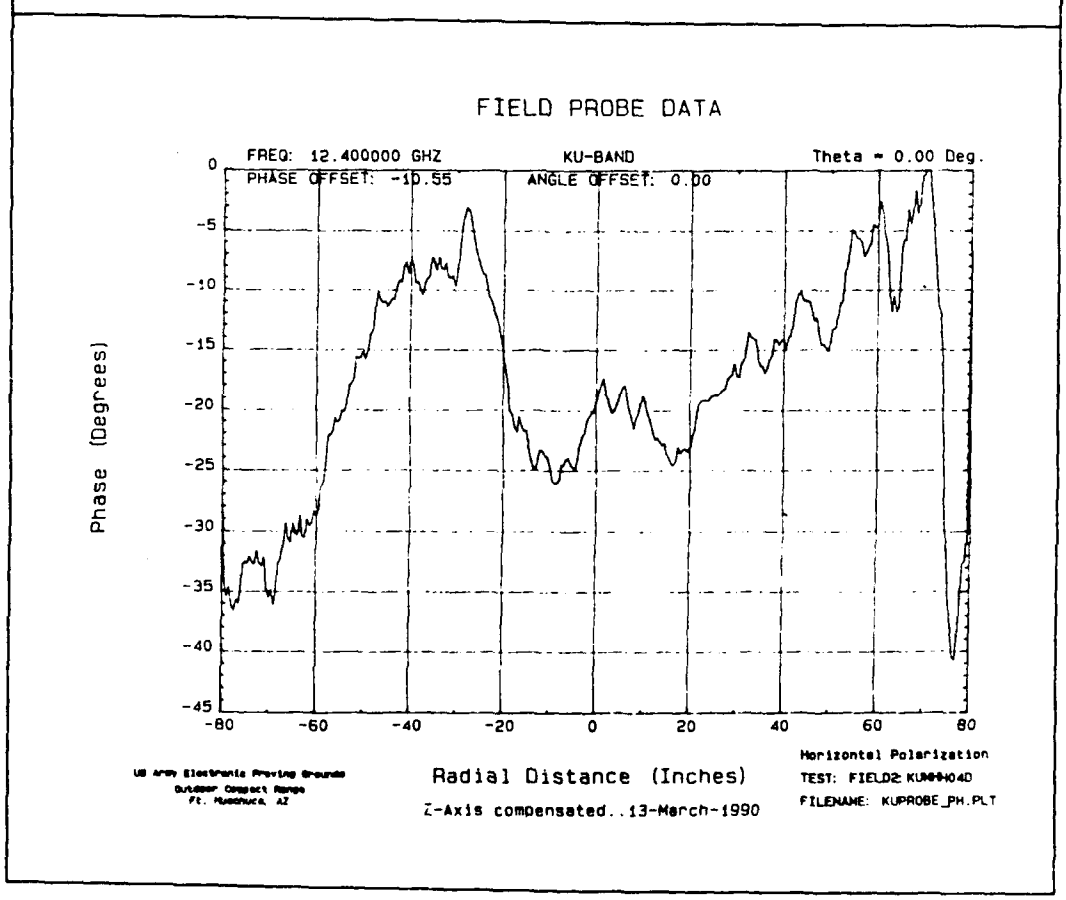

FIELD PROBE DATA
FREQ: 15.000000 GHZ
KU-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -41.67
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
Vertical Polarization
TEST: FIELD2 KUMVH04B
FILENAME: KUPROBE_PH.PLT

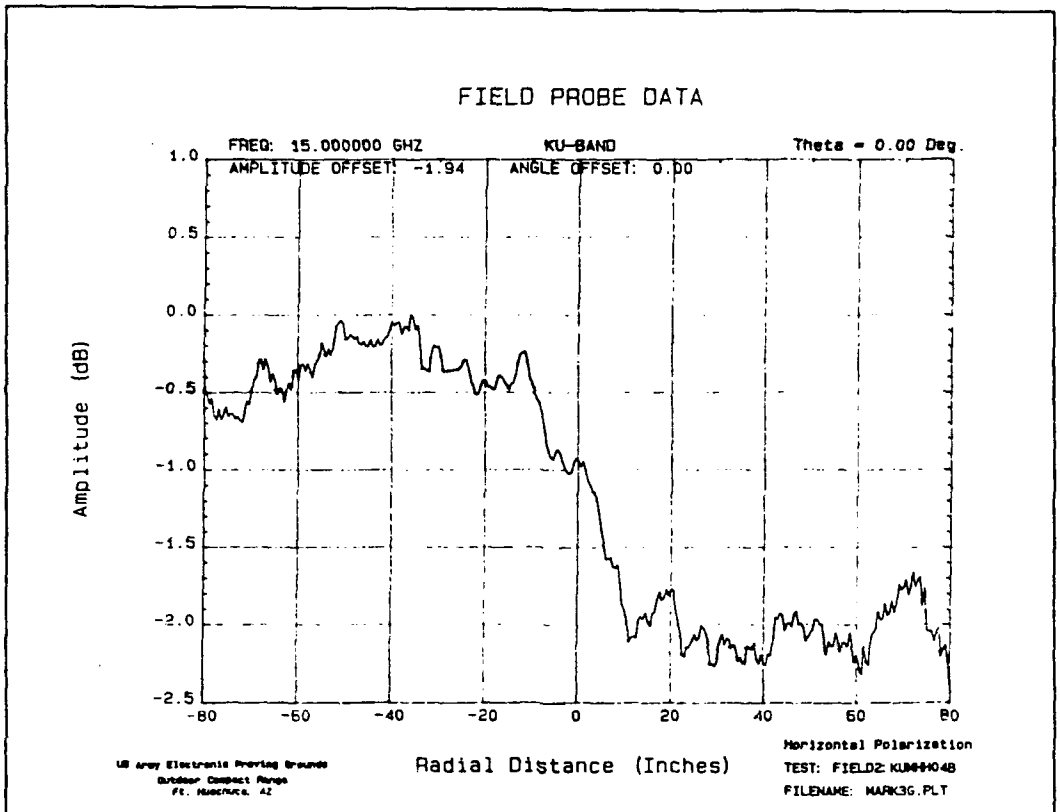

FIELD PROBE DATA
FREQ: 17.999000 GHZ
KU-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: -0.41
ANGLE OFFSET: 0.00
Amplitude (dB)
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2: KUMVH04C
FILENAME: MARK3J.PLT
FIELD PROBE DATA
FREQ: 17.999000 GHZ
KU-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -28.70
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
Vertical Polarization
TEST: FIELD2: KUMVH04C
FILENAME: KUPROBE_PH.PLT

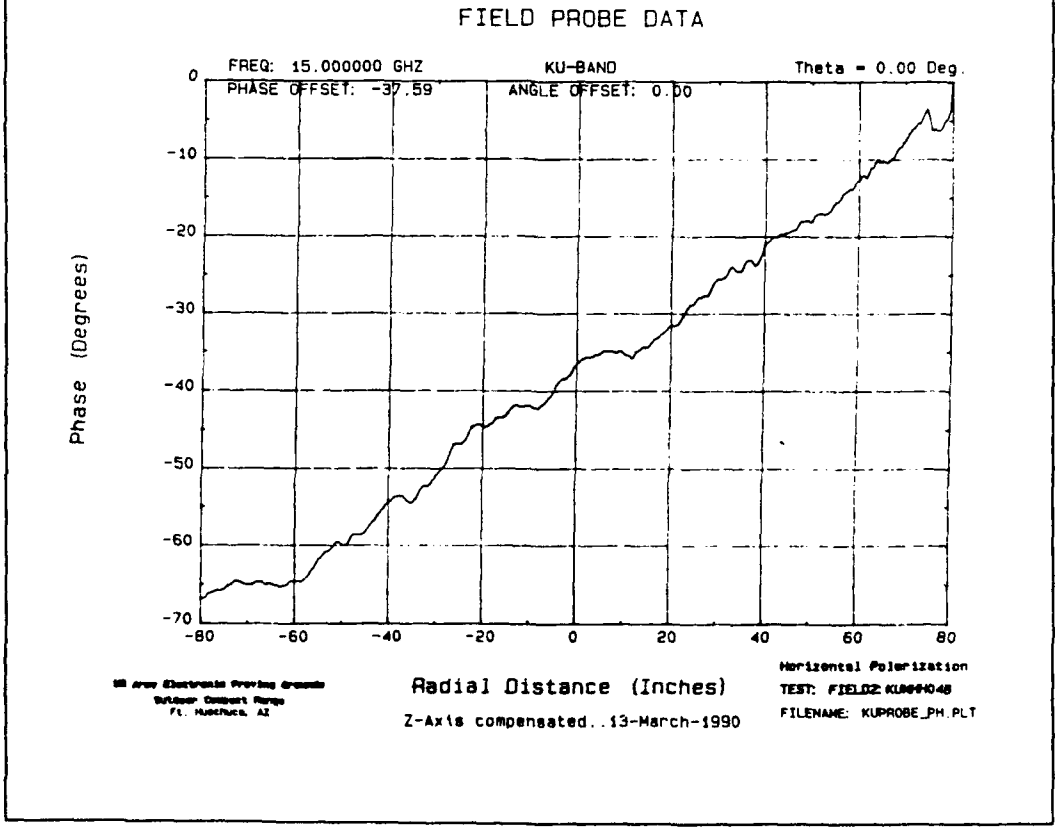

FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: -1.26
ANGLE OFFSET: 0.00
Amplitude (dB)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KUMMH04A
FILENAME: MARK3I.PLT

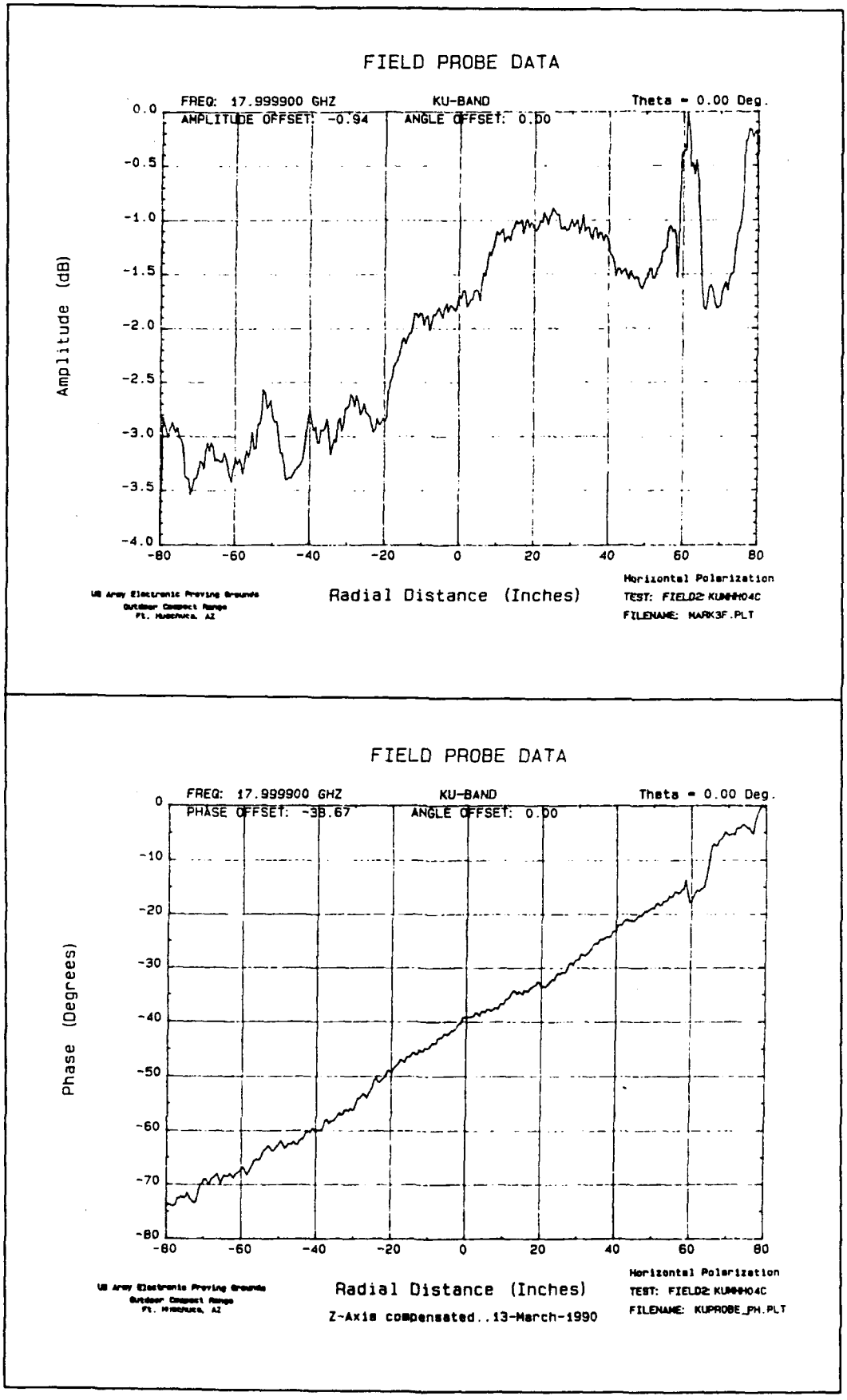

FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -13.13
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated 13-March-1990
Horizontal Polarization
TEST: FIELD2 KUMMH04A
FILENAME: KUPROBE_PH.PLT

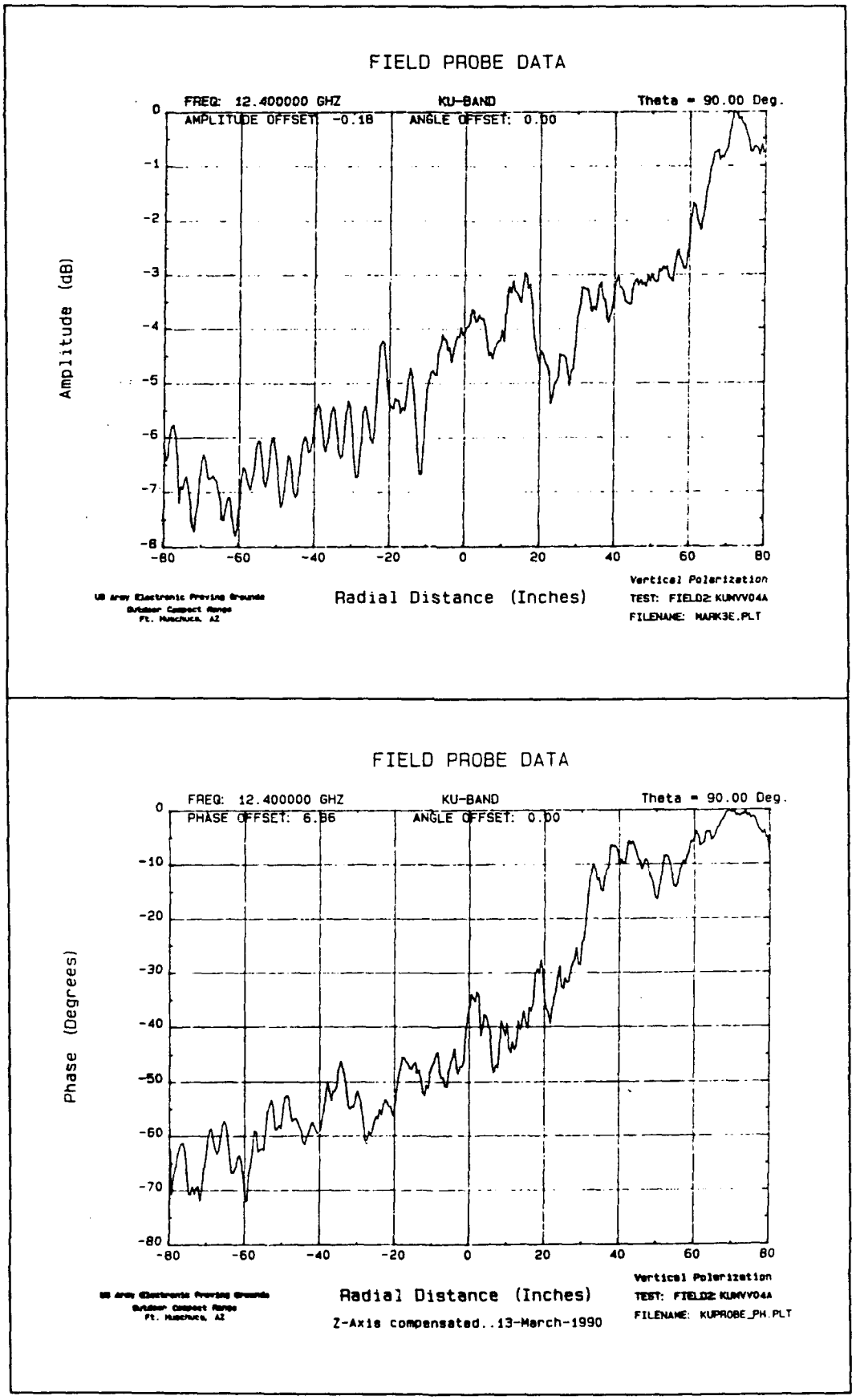

FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: -0.41
ANGLE OFFSET: 0.00
Amplitude (dB)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 KUHH04D
FILENAME: MARK3H.PLT

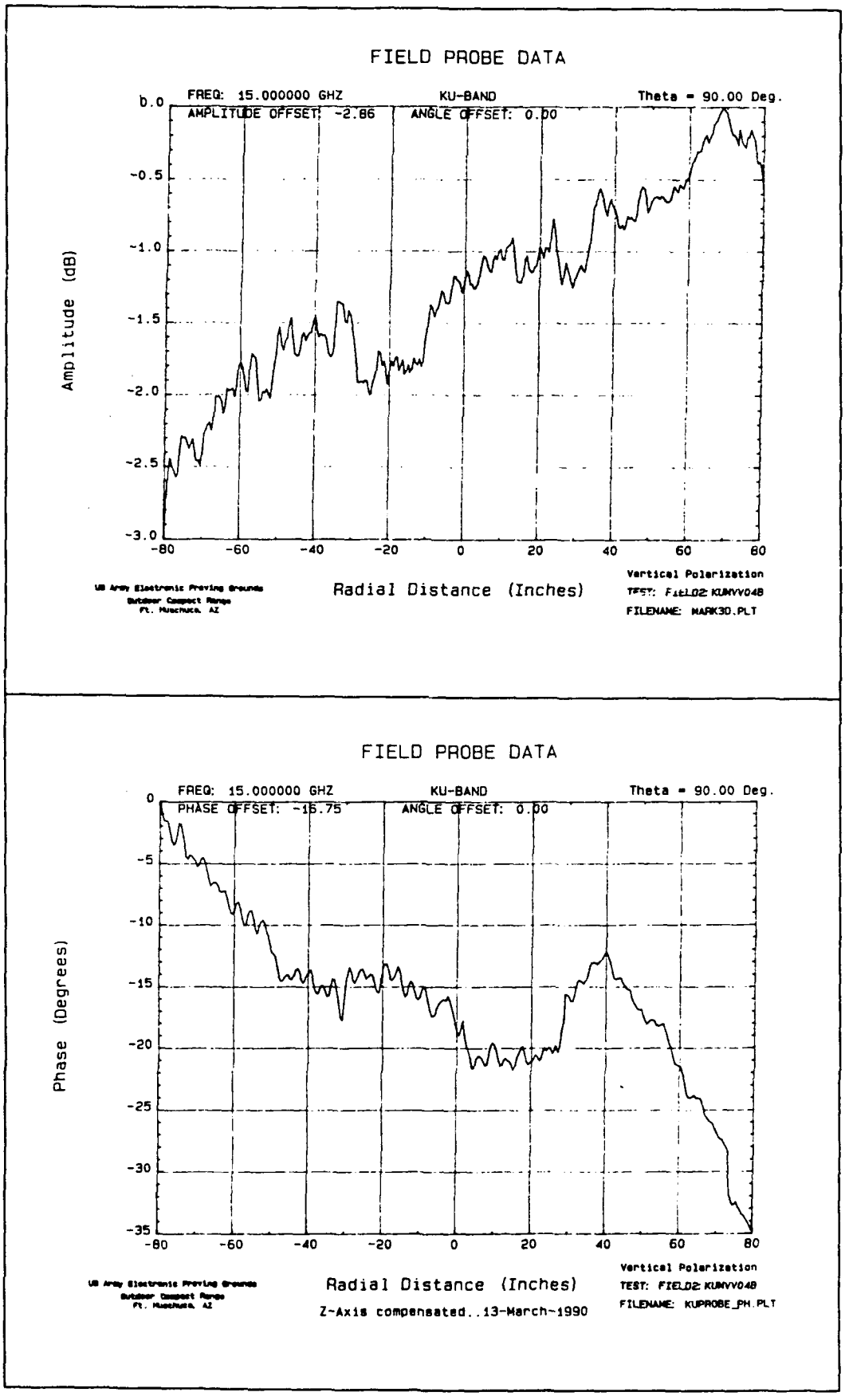

FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -10.55
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 KUHH04D
FILENAME: KUPROBE_PH.PLT

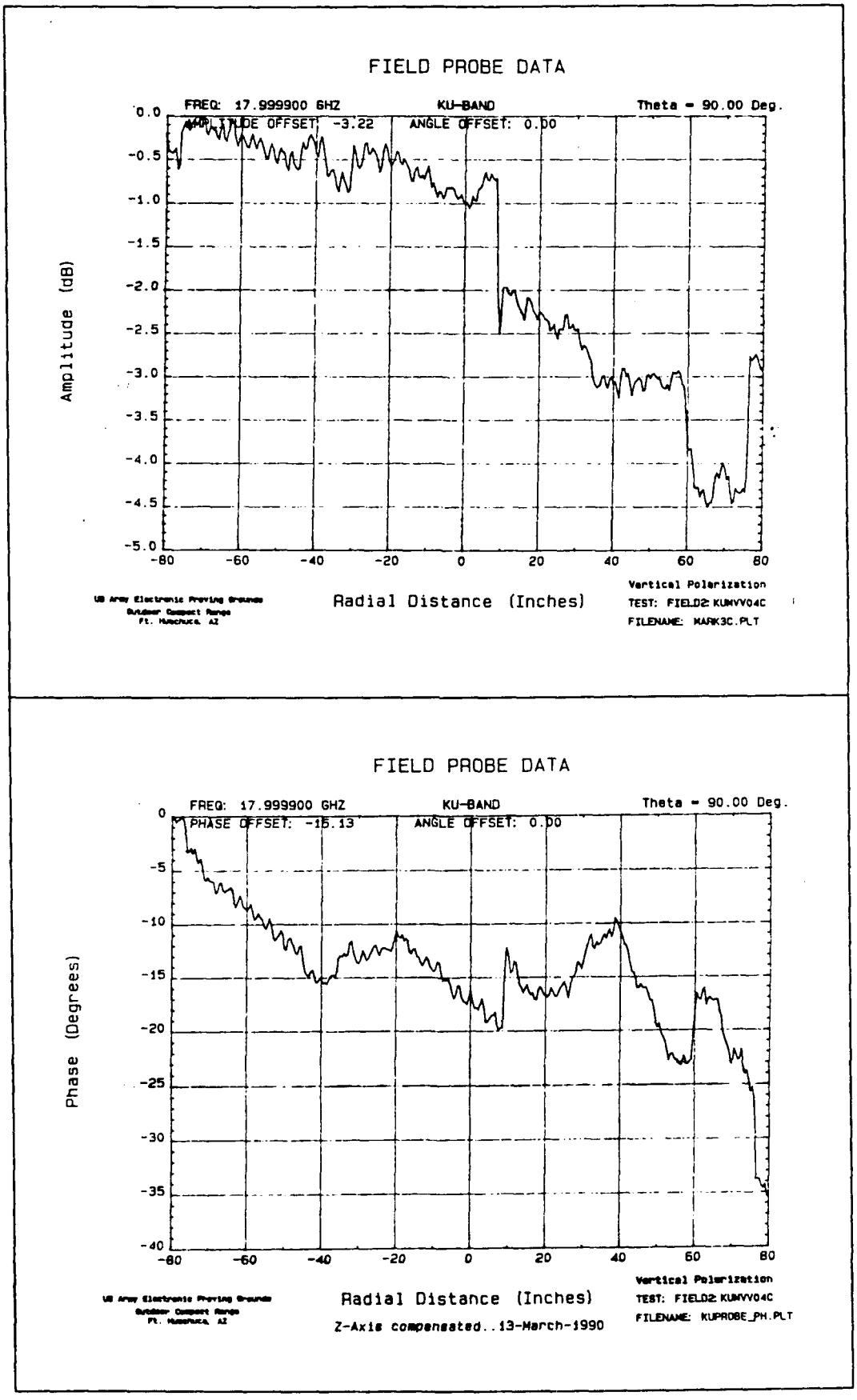

FIELD PROBE DATA
FREQ: 15.000000 GHZ
KU-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: -1.94
ANGLE OFFSET: 0.00
Amplitude (dB)
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KU04H04B
FILENAME: MARK3G.PLT

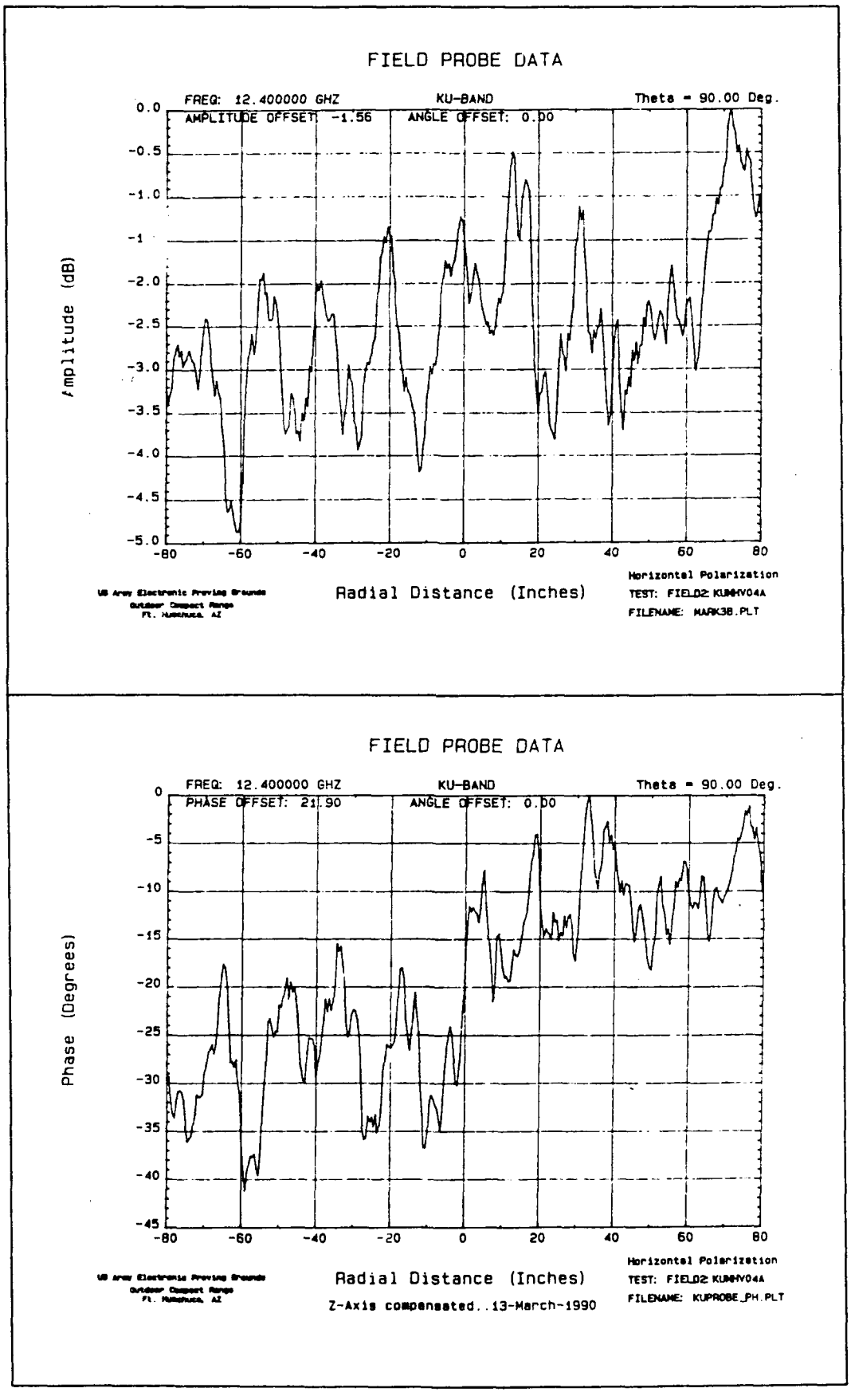

FIELD PROBE DATA
FREQ: 15.000000 GHZ
KU-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -37.59
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
Horizontal Polarization
TEST: FIELD2 KU04H04B
FILENAME: KUPROBE_PH.PLT

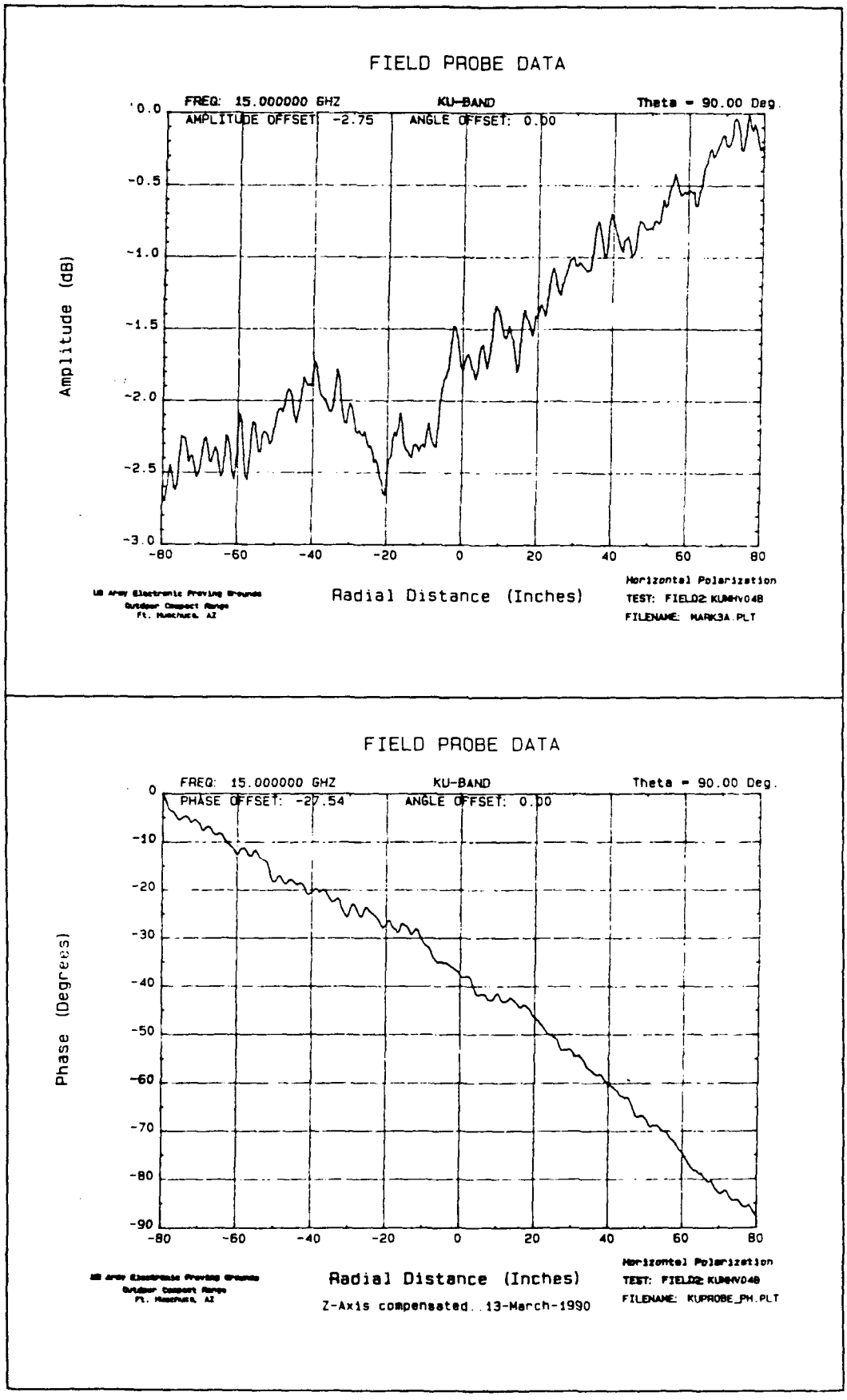

FIELD PROBE DATA
FREQ: 17.999900 GHZ
KU-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: -0.94
ANGLE OFFSET: 0.00
Amplitude (dB)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 KU####04C
FILENAME: MARK3F.PLT
FIELD PROBE DATA
FREQ: 17.999900 GHZ
KU-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -38.67
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 KU####04C
FILENAME: KUPROBE_PH.PLT

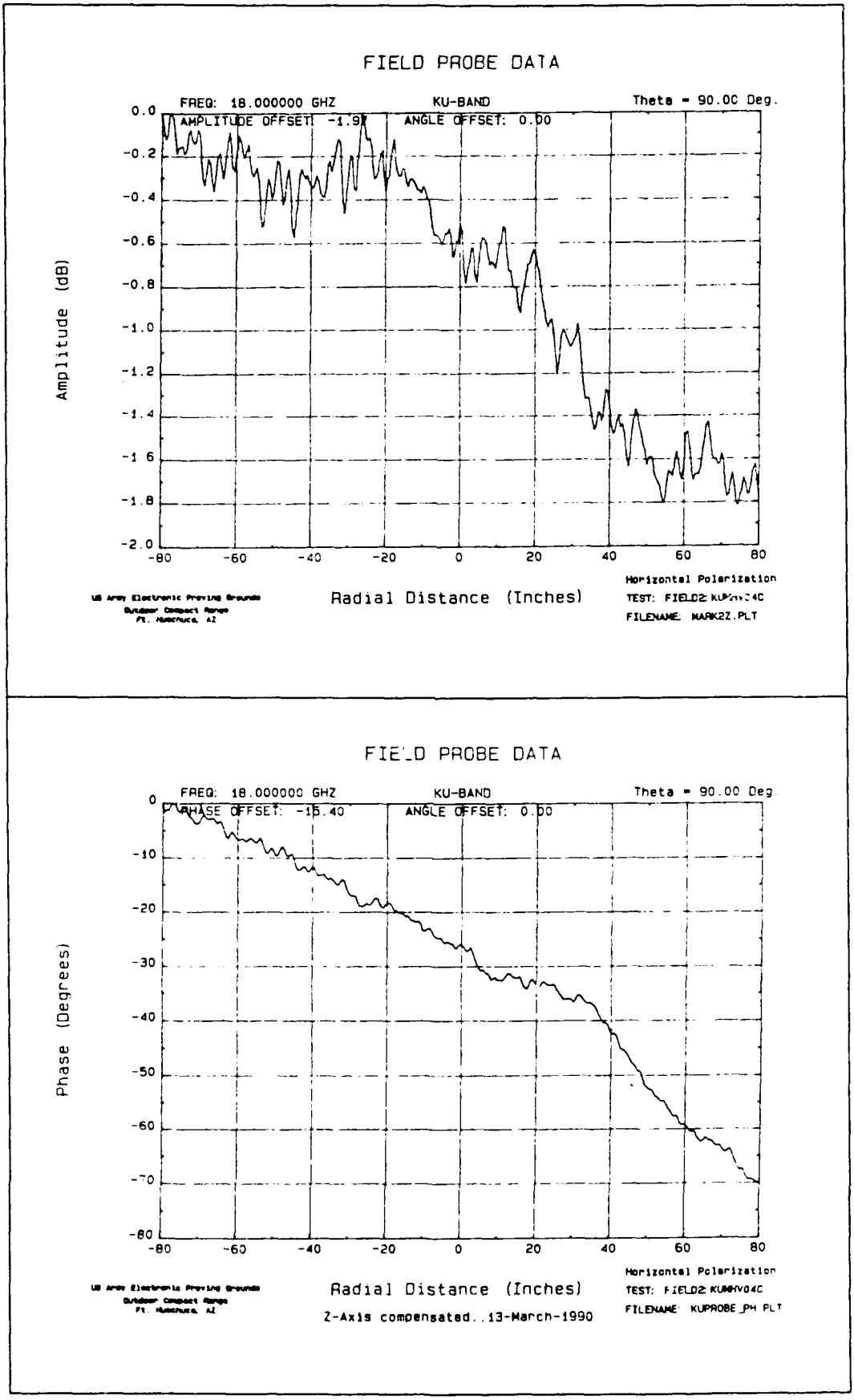

FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: -0.18
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-7
-8
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KUMVV04A
FILENAME: MARK3E.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 6.86
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
Vertical Polarization
TEST: FIELD2 KUMVV04A
FILENAME: KUPROBE_PH.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ

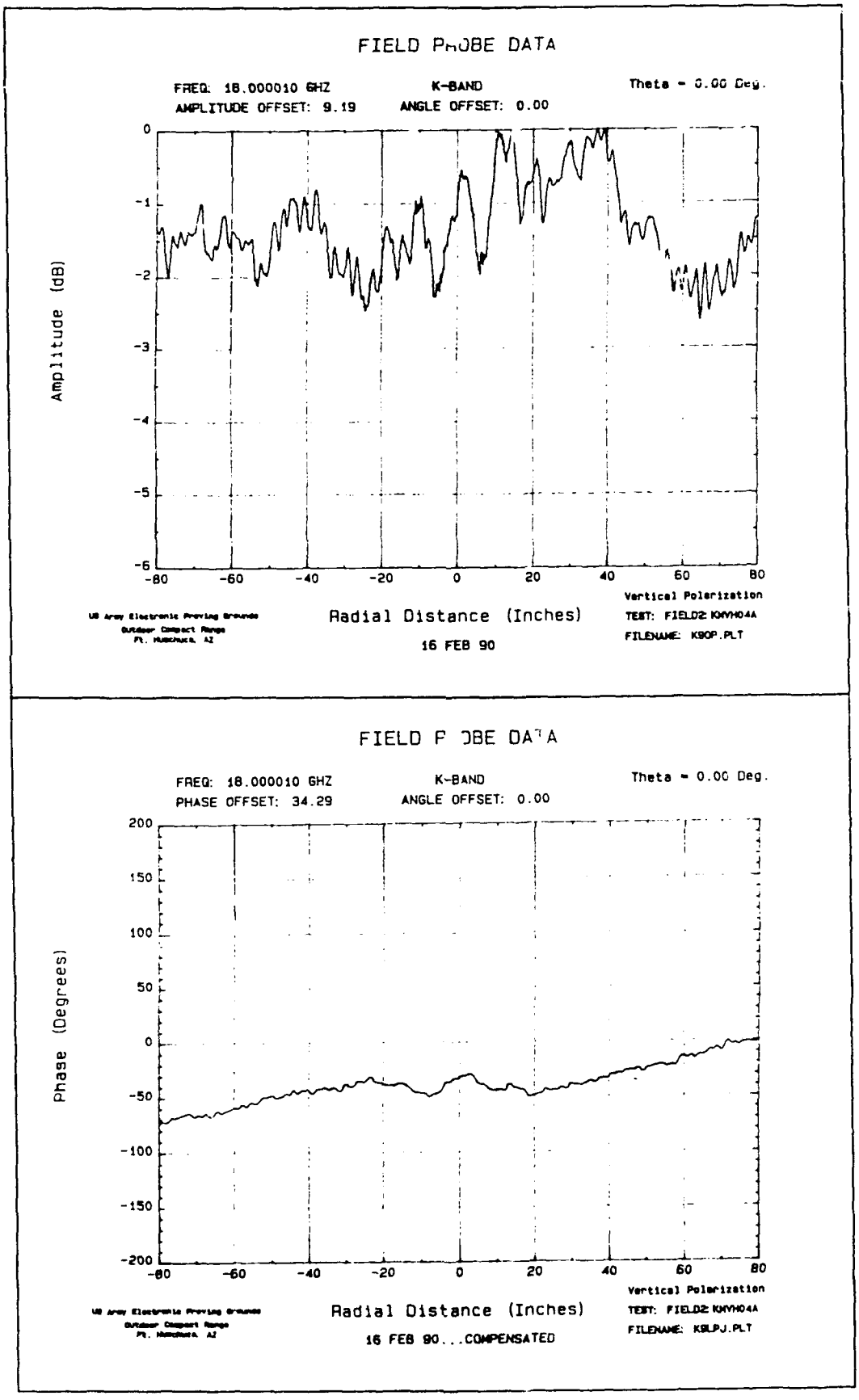

FIELD PROBE DATA
FREQ: 15.000000 GHZ
KU-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: -2.86
ANGLE OFFSET: 0.00
Amplitude (dB)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KUMVV04B
FILENAME: MARK3D.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
FIELD PROBE DATA
FREQ: 15.000000 GHZ
KU-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -15.75
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
Vertical Polarization
TEST: FIELD2 KUMVV04B
FILENAME: KUPROBE_PH.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ

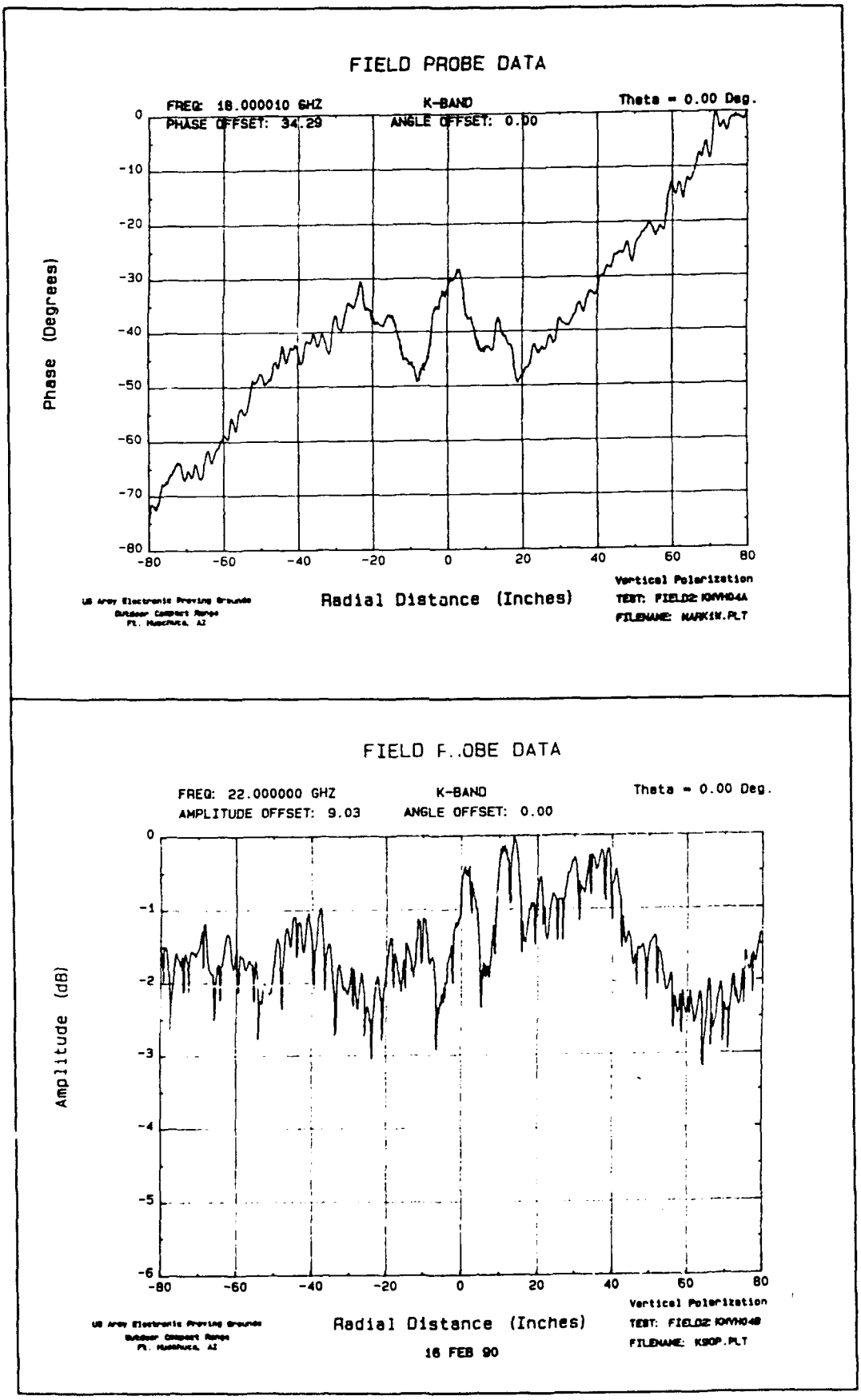

FIELD PROBE DATA
FREQ: 17.999900 GHZ
KU-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: -3.22
ANGLE OFFSET: 0.00
Amplitude (dB)
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2: KUMVV04C
FILENAME: MARK3C.PLT
FIELD PROBE DATA
FREQ: 17.999900 GHZ
KU-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -15.13
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2: KUMVV04C
FILENAME: KUPROBE_PH.PLT

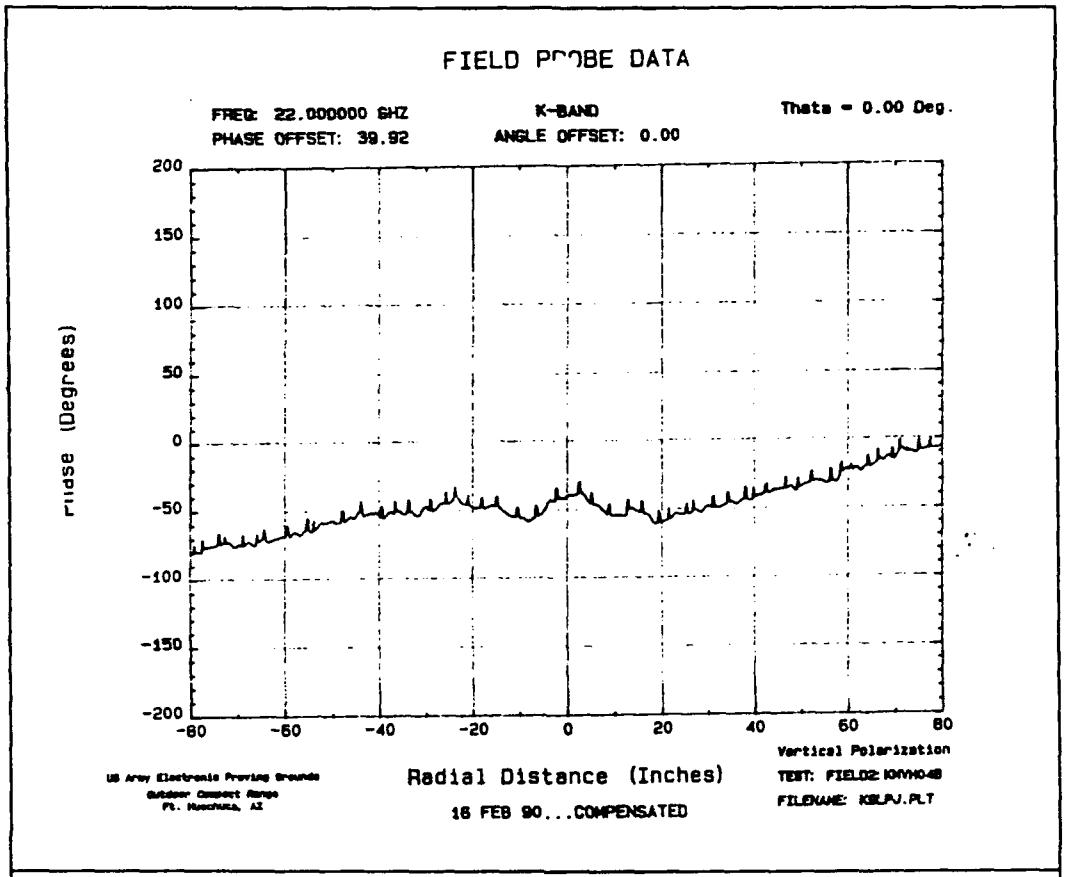

FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: -1.56
ANGLE OFFSET: 0.00
Amplitude (dB)
0.0
-0.5
-1.0
-1
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KUHV04A
FILENAME: MARK38.PLT
FIELD PROBE DATA
FREQ: 12.400000 GHZ
KU-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 21.90
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
Horizontal Polarization
TEST: FIELD2 KUHV04A
FILENAME: KUPROBE_PH.PLT

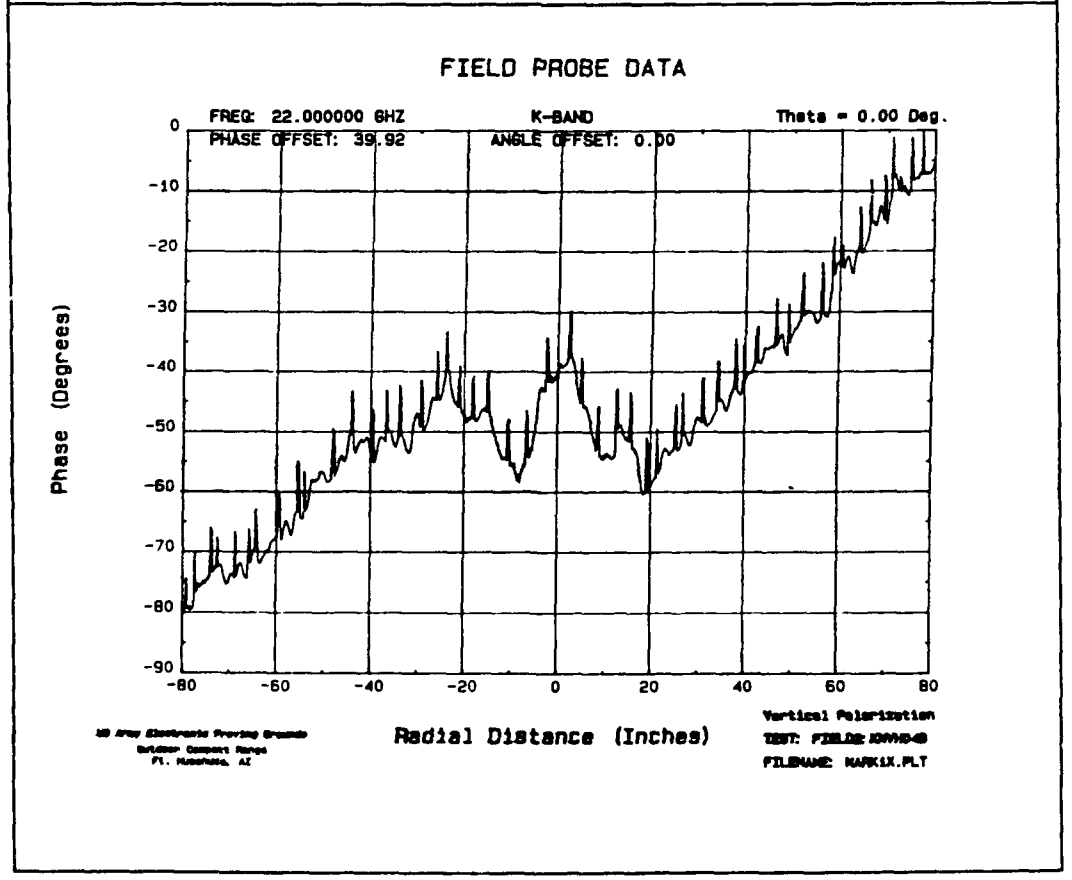

FIELD PROBE DATA
FREQ: 15.000000 GHZ
KU-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: -2.75
ANGLE OFFSET: 0.00
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
Amplitude (dB)
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KUHHV048
FILENAME: MARK3A.PLT
FIELD PROBE DATA
FREQ: 15.000000 GHZ
KU-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -27.54
ANGLE OFFSET: 0.00
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Phase (Degrees)
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
Horizontal Polarization
TEST: FIELD2 KUHHV048
FILENAME: KUPROBE_PH.PLT

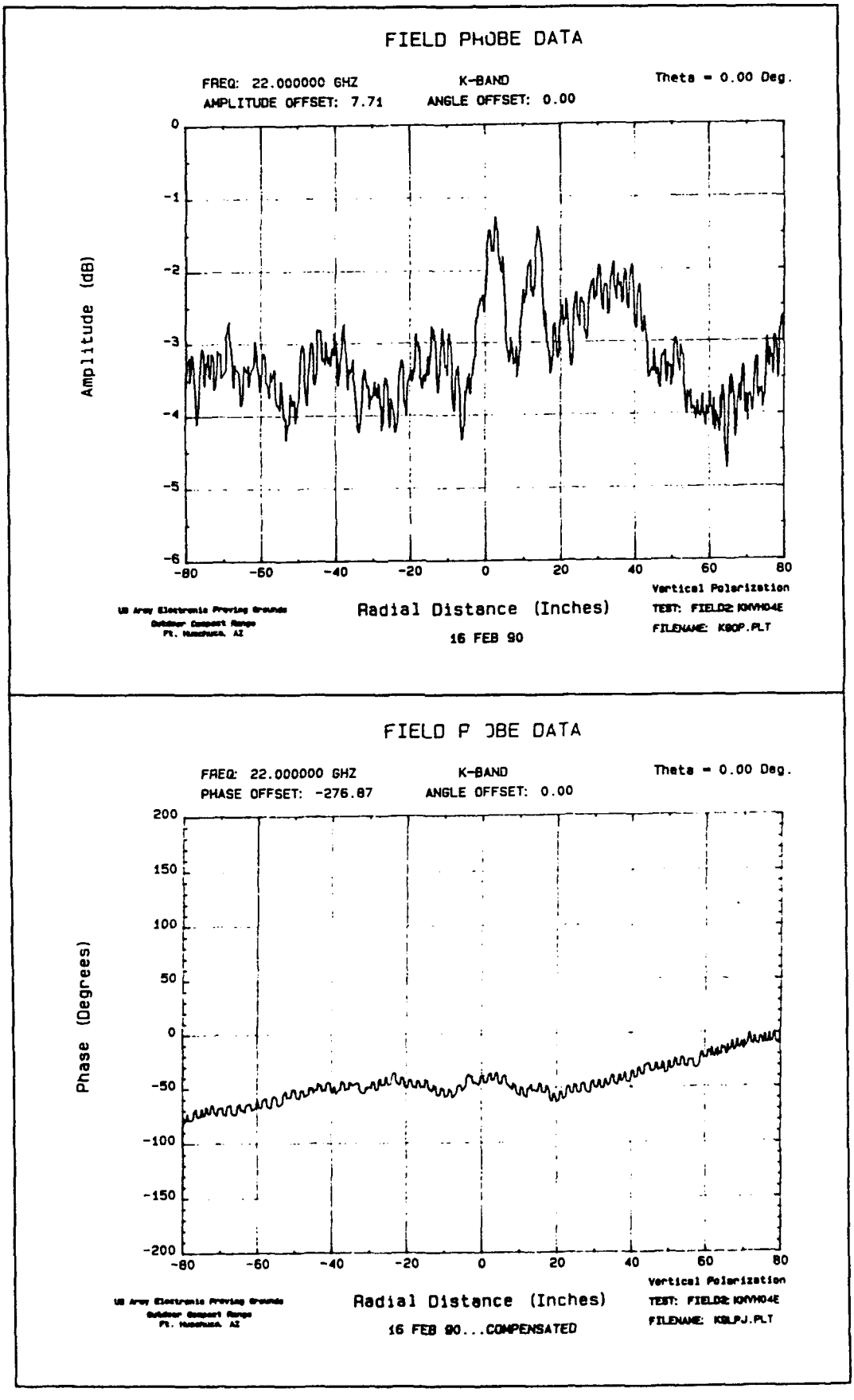

FIELD PROBE DATA
FREQ: 18.000000 GHZ
KU-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: -1.97
ANGLE OFFSET: 0.00
Amplitude (dB)
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2: KUP
FILENAME: MARK2Z.PLT
FIELD PROBE DATA
FREQ: 18.000000 GHZ
KU-BAND
Theta = 90.00 Deg
PHASE OFFSET: -15.40
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Z-Axis compensated..13-March-1990
Horizontal Polarization
TEST: FIELD2: KUP
FILENAME: KUPROBE_PH.PLT

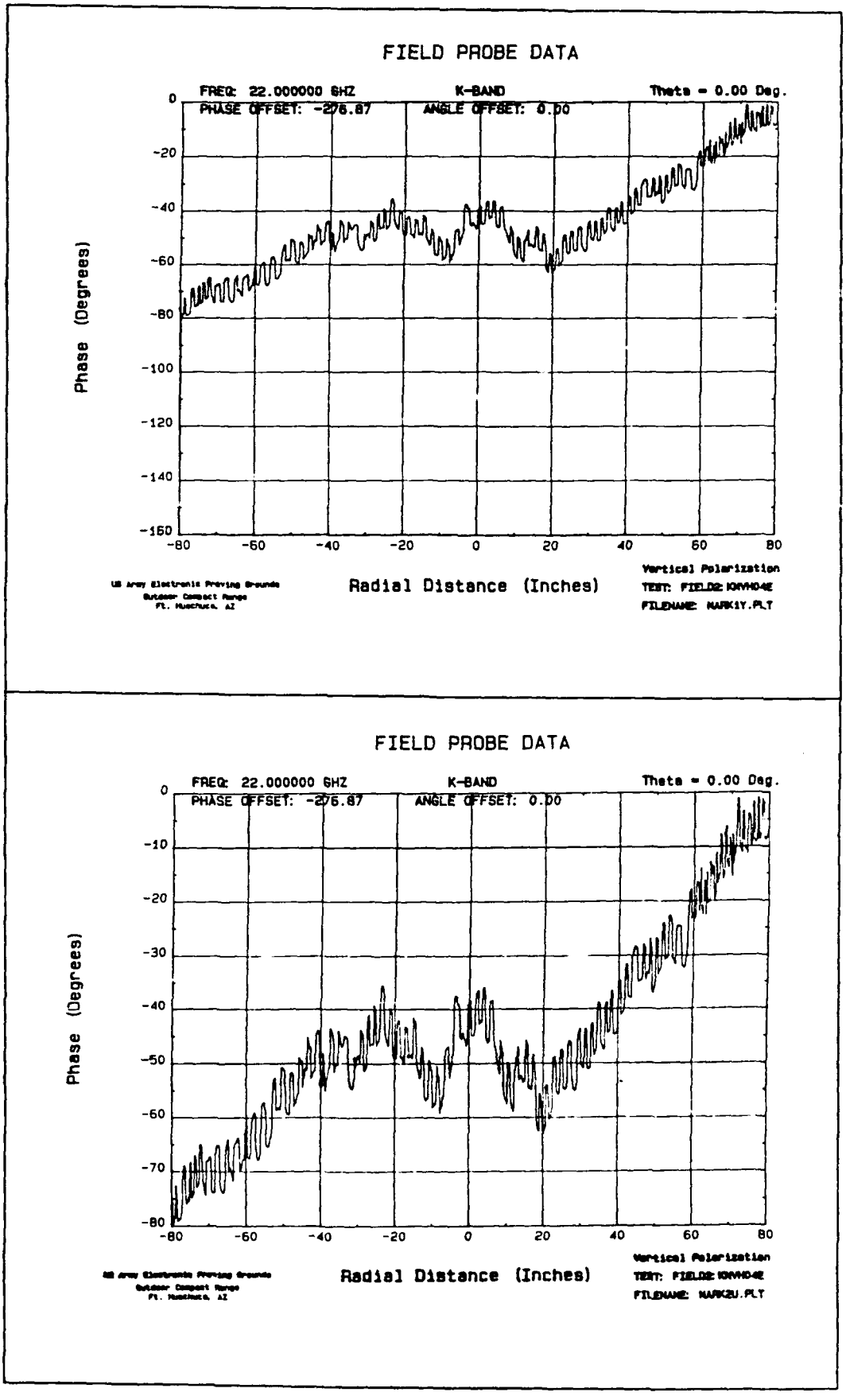

FIELD PROBE DATA
FREQ: 18.000010 GHZ
K-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 9.19
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVH04A
FILENAME: K90P.PLT
16 FEB 90
FIELD PROBE DATA
FREQ: 18.000010 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 34.29
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVH04A
FILENAME: K9LPJ.PLT
16 FEB 90...COMPENSATED

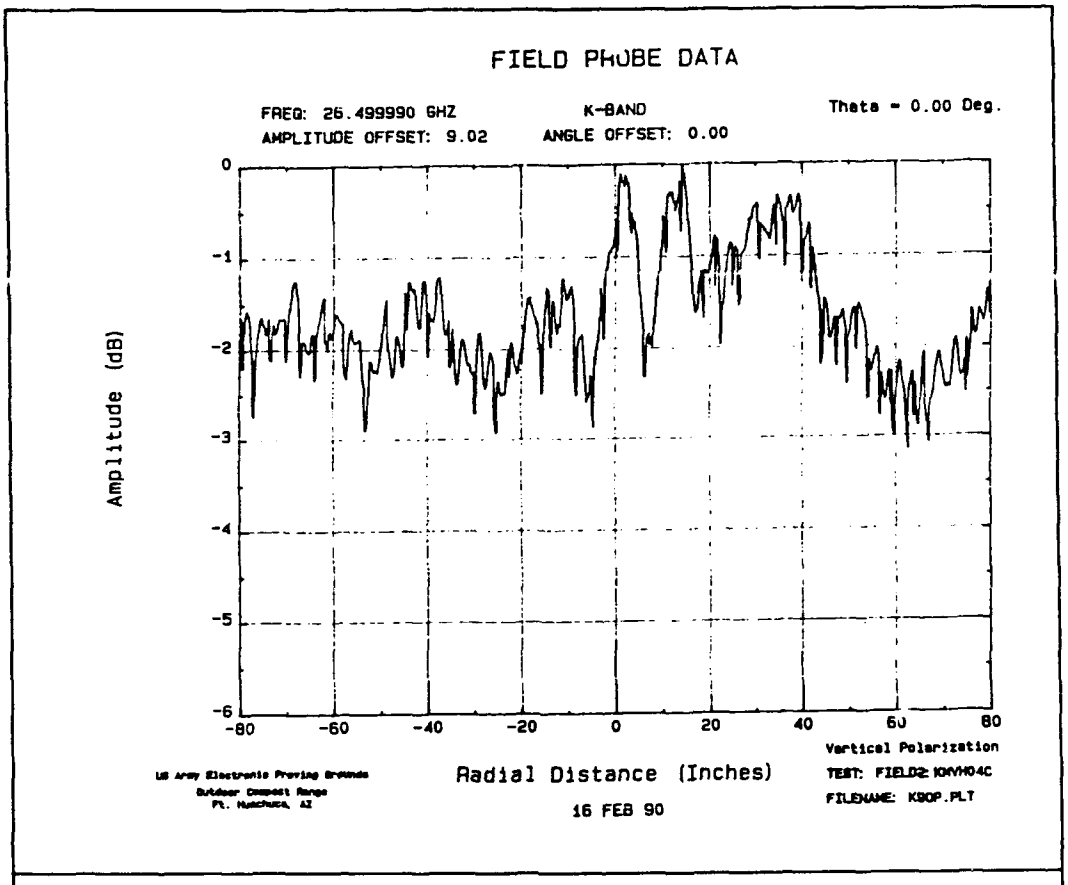

FIELD PROBE DATA
FREQ: 18.000010 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 34.29
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KMVH04A
FILENAME: MARKIW.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
FIELD P..OBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 9.03
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KMVH04B
FILENAME: KBOP.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
16 FEB 90

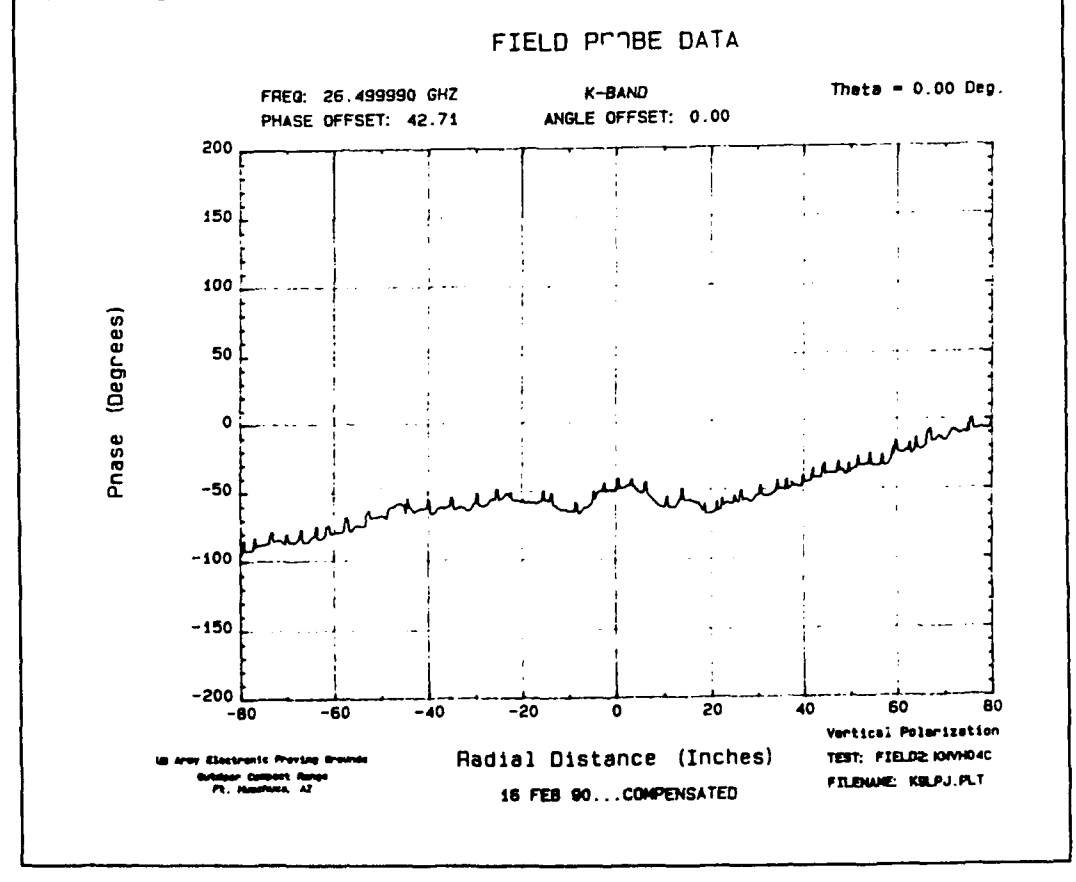

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 39.92
ANGLE OFFSET: 0.00
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Phase (Degrees)
Radial Distance (Inches)
Vertical Polarization
16 FEB 90...COMPENSATED

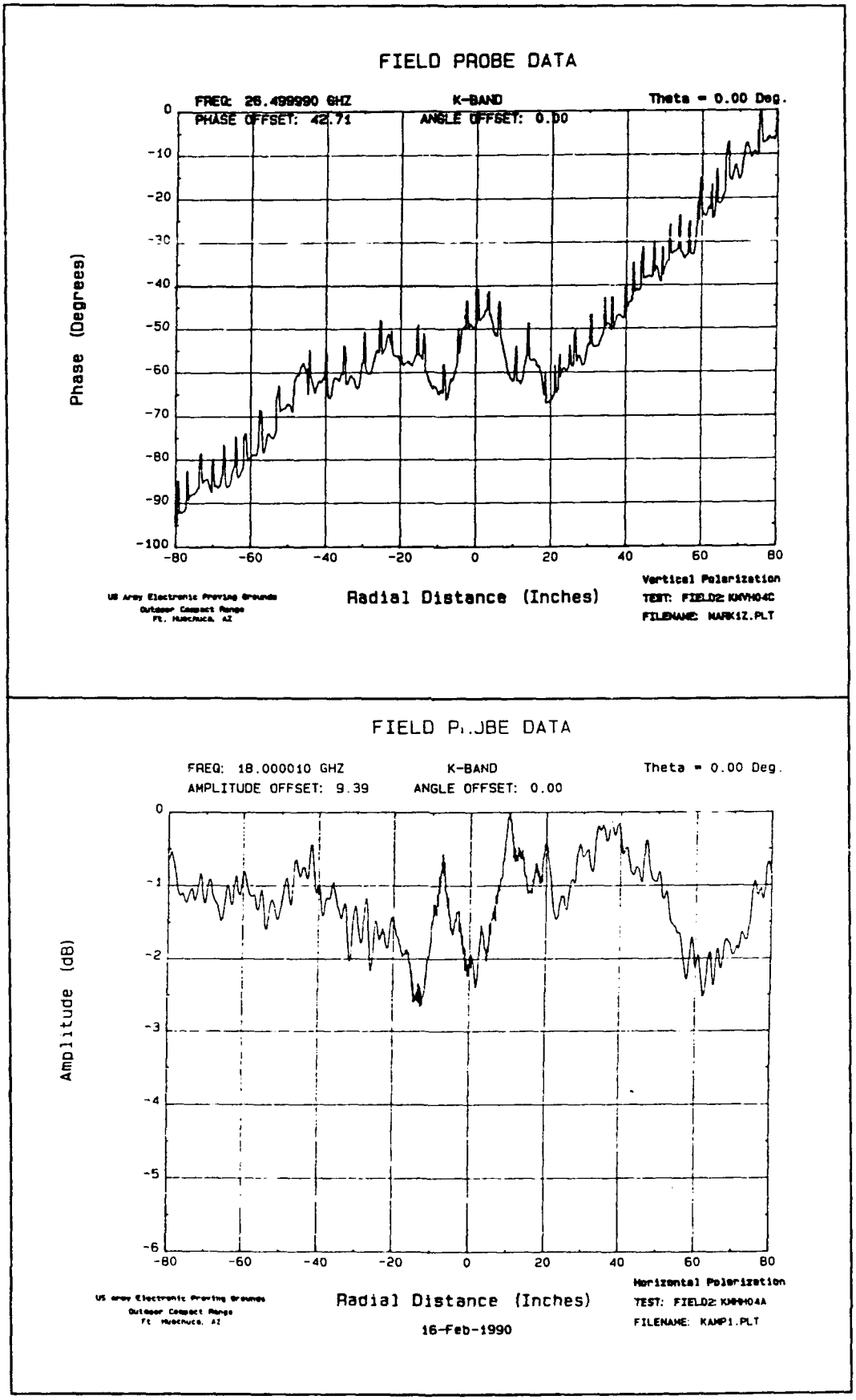

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 39.92
ANGLE OFFSET: 0.00
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-80
-60
-40
-20
0
20
40
60
80
Phase (Degrees)
Radial Distance (Inches)
Vertical Polarization

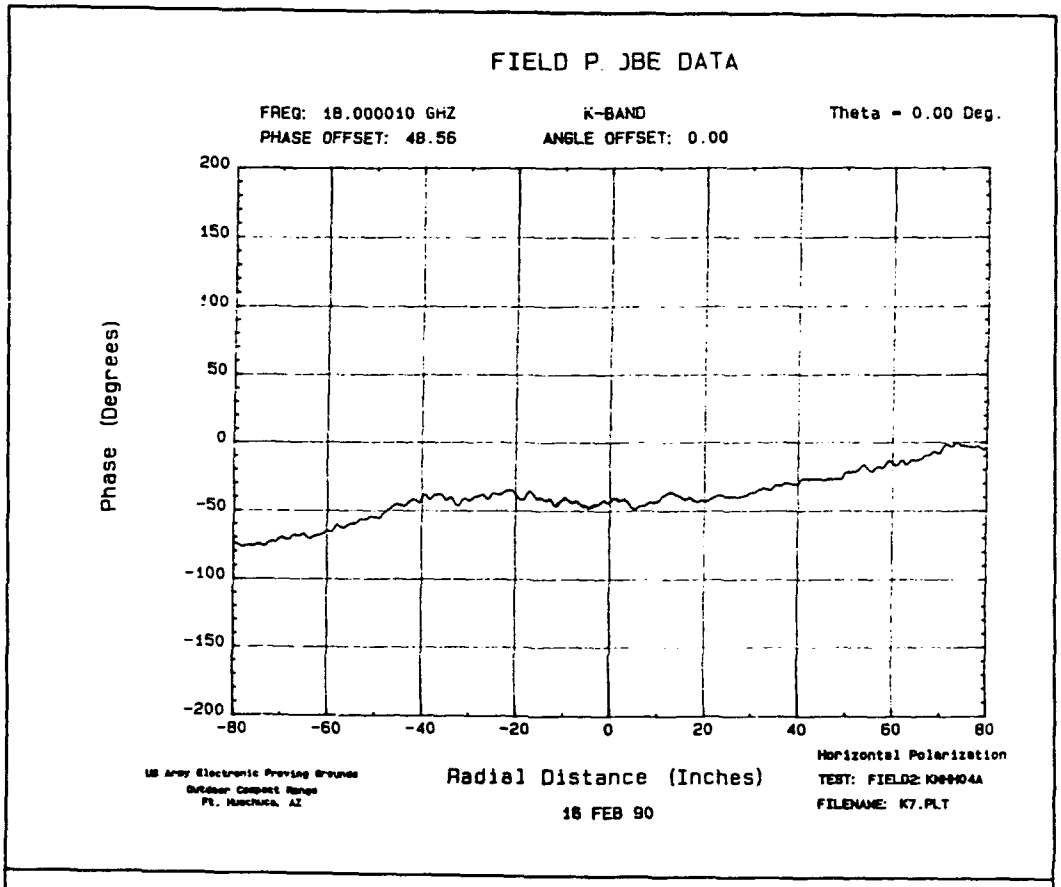

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 7.71
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVH04E
FILENAME: K8OP.PLT
16 FEB 90
FIELD P OBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -276.87
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVH04E
FILENAME: K8LPJ.PLT
16 FEB 90...COMPENSATED

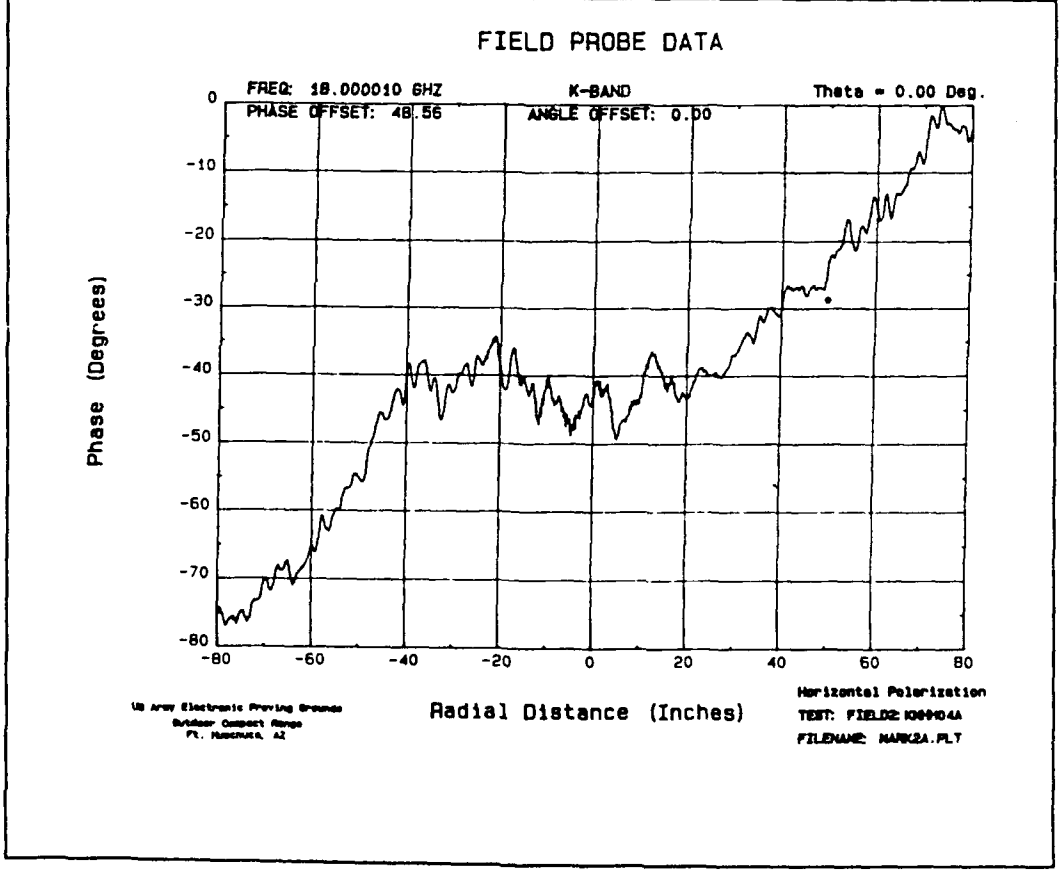

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -276.87
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-140
-160
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2: KHVH04E
FILENAME: NARK1Y.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -276.87
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2: KHVH04E
FILENAME: NARK2U.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ

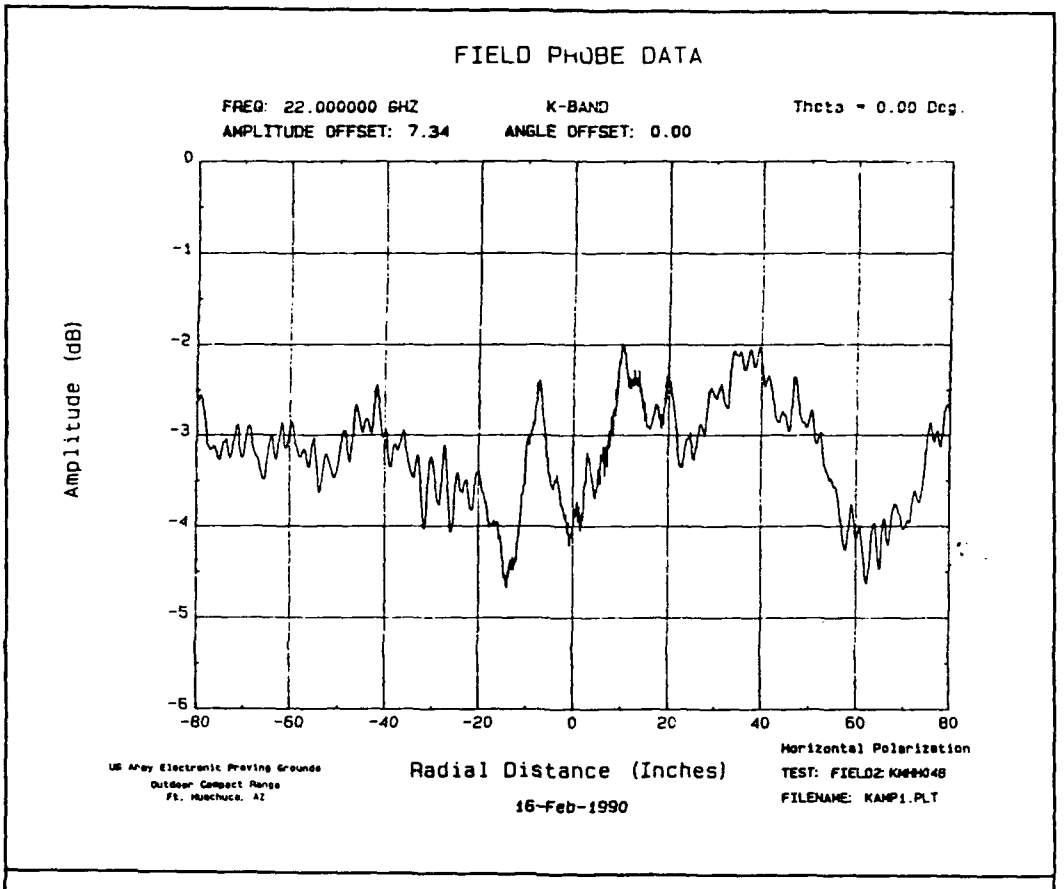

FIELD PROBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 9.02
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVH04C
FILENAME: K90P.PLT
16 FEB 90

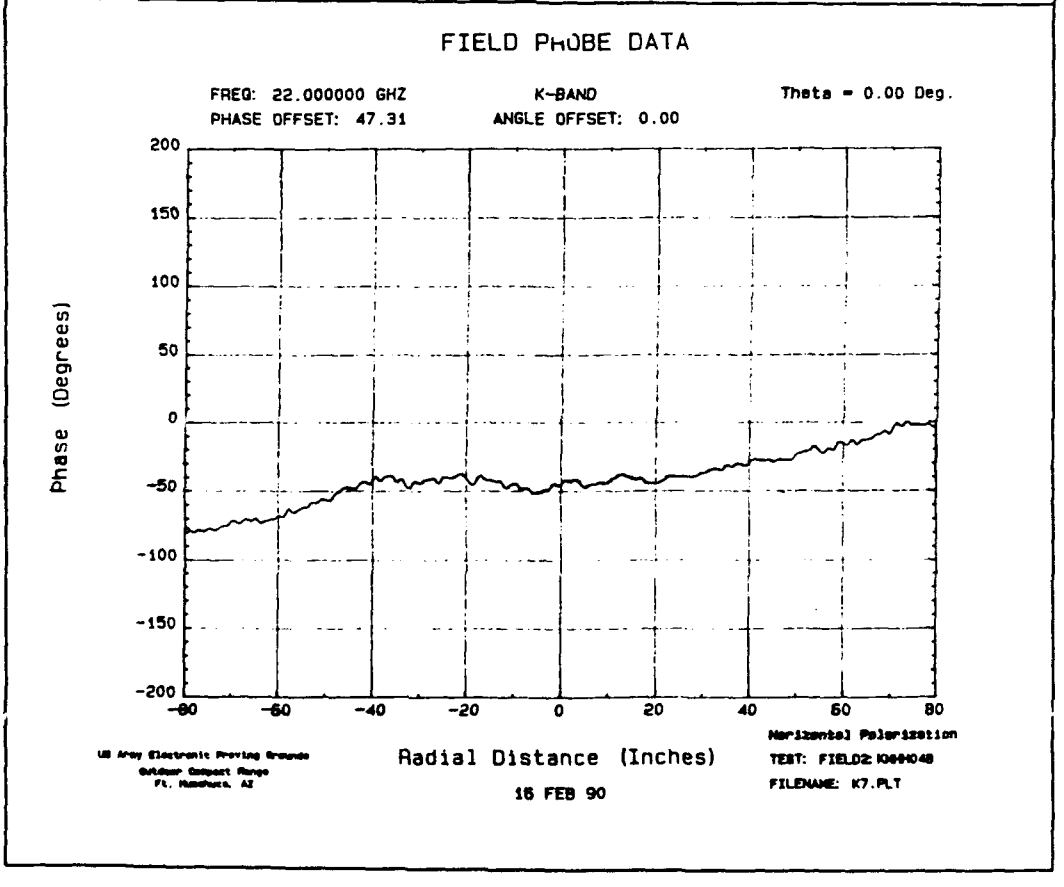

FIELD PROBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 42.71
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVH04C
FILENAME: K90PJ.PLT
16 FEB 90...COMPENSATED

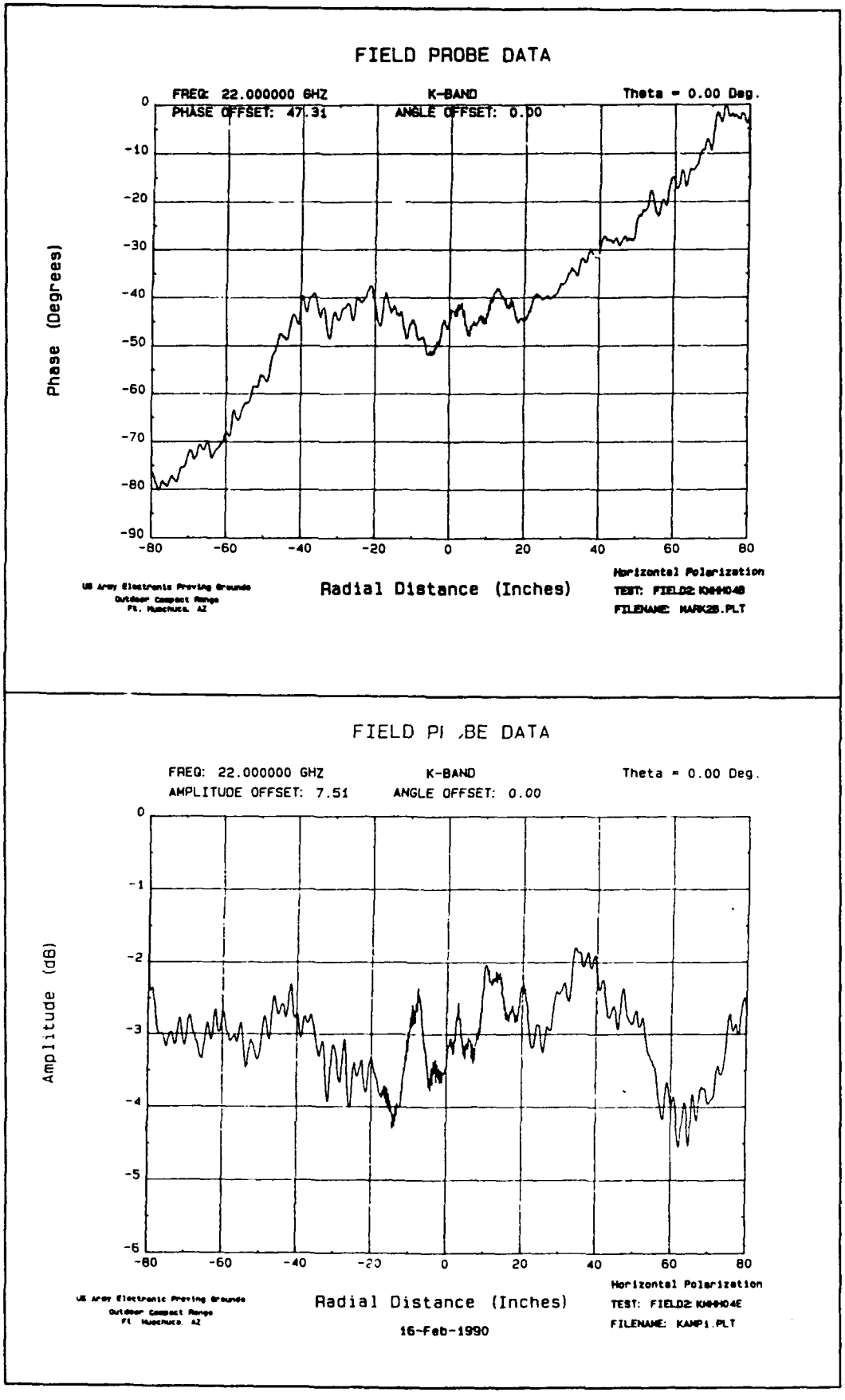

FIELD PROBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 42.71
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2 KMVH04C
FILENAME: MARK1Z.PLT
FIELD PROBE DATA
FREQ: 18.000010 GHZ
K-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 9.39
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 KMHH04A
FILENAME: KAMP1.PLT
16-Feb-1990

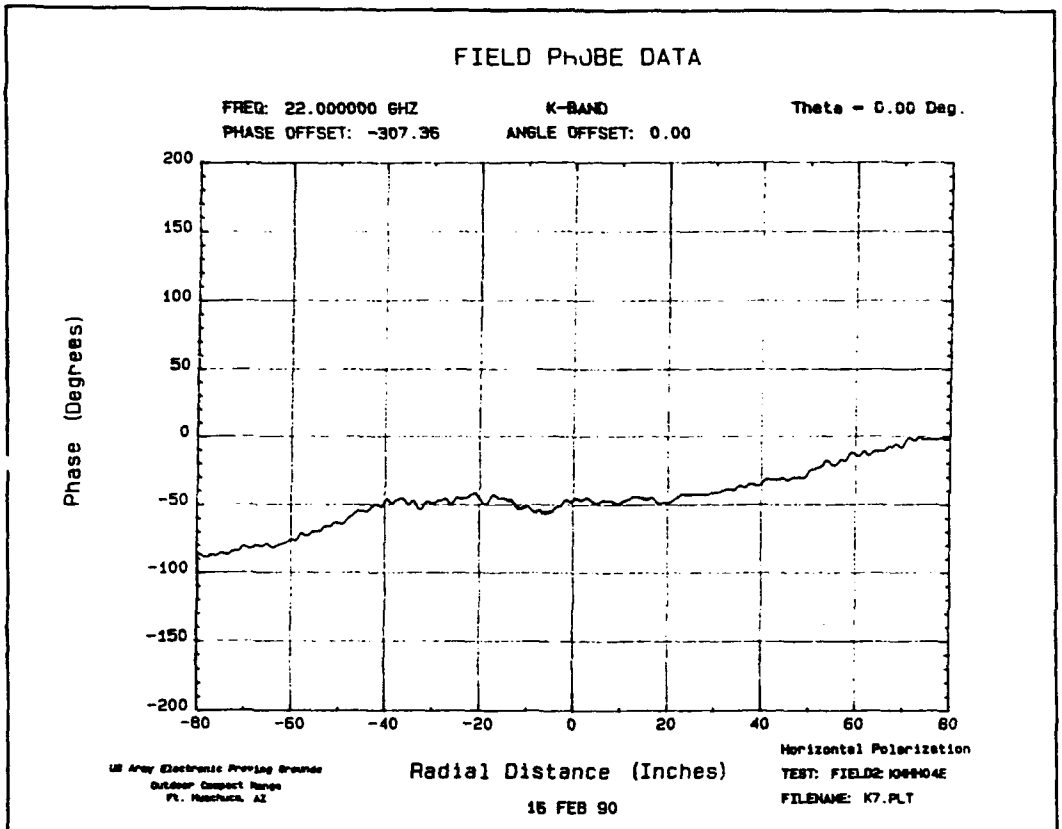

FIELD P. JBE DATA
FREQ: 18.000010 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 48.56
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 K000104A
FILENAME: K7.PLT

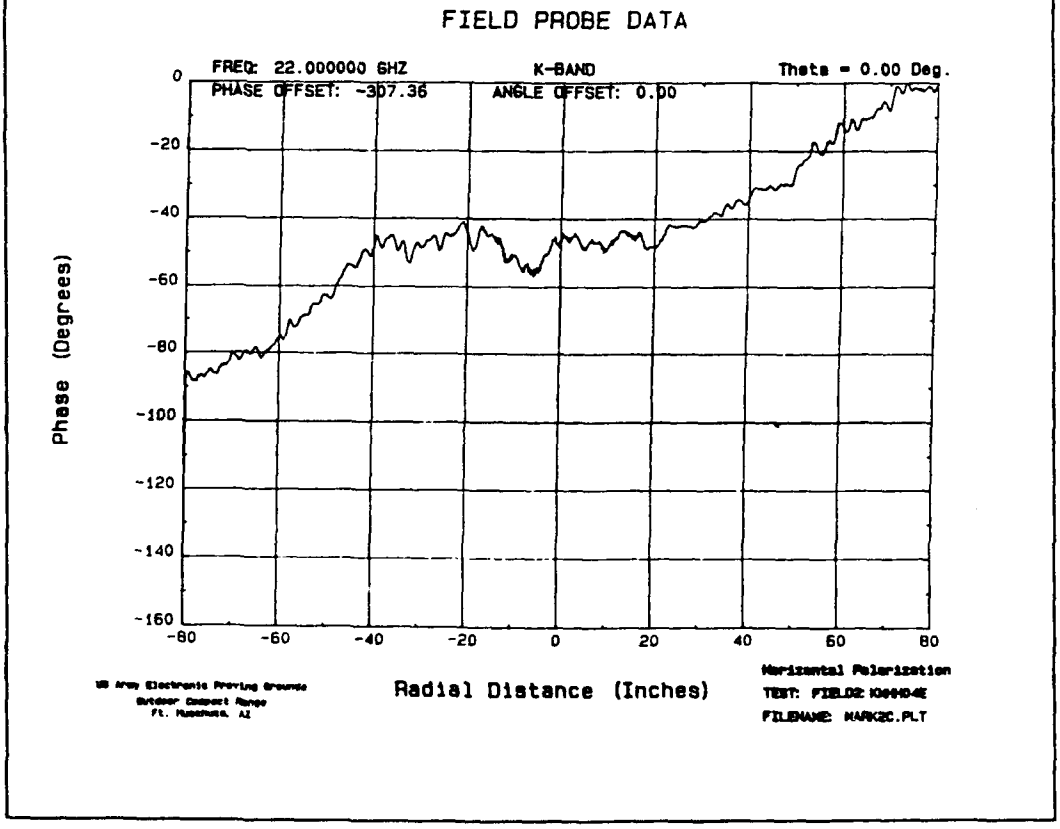

FIELD PROBE DATA
FREQ: 18.000010 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 48.56
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 K000104A
FILENAME: MARK2A.PLT

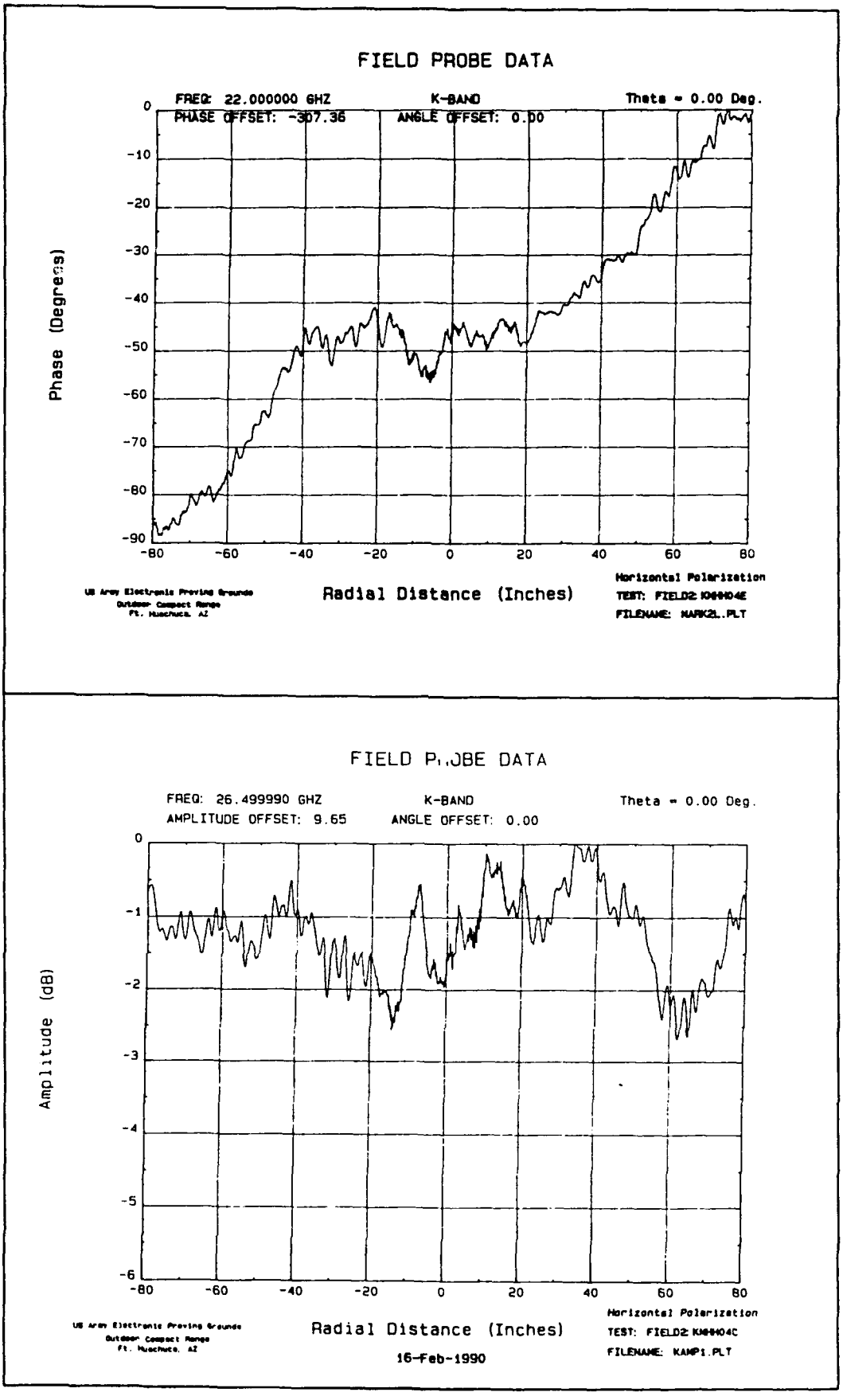

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 7.34
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Radial Distance (Inches)
16-Feb-1990
Horizontal Polarization
TEST: FIELD2 KHHH048
FILENAME: KAMP1.PLT

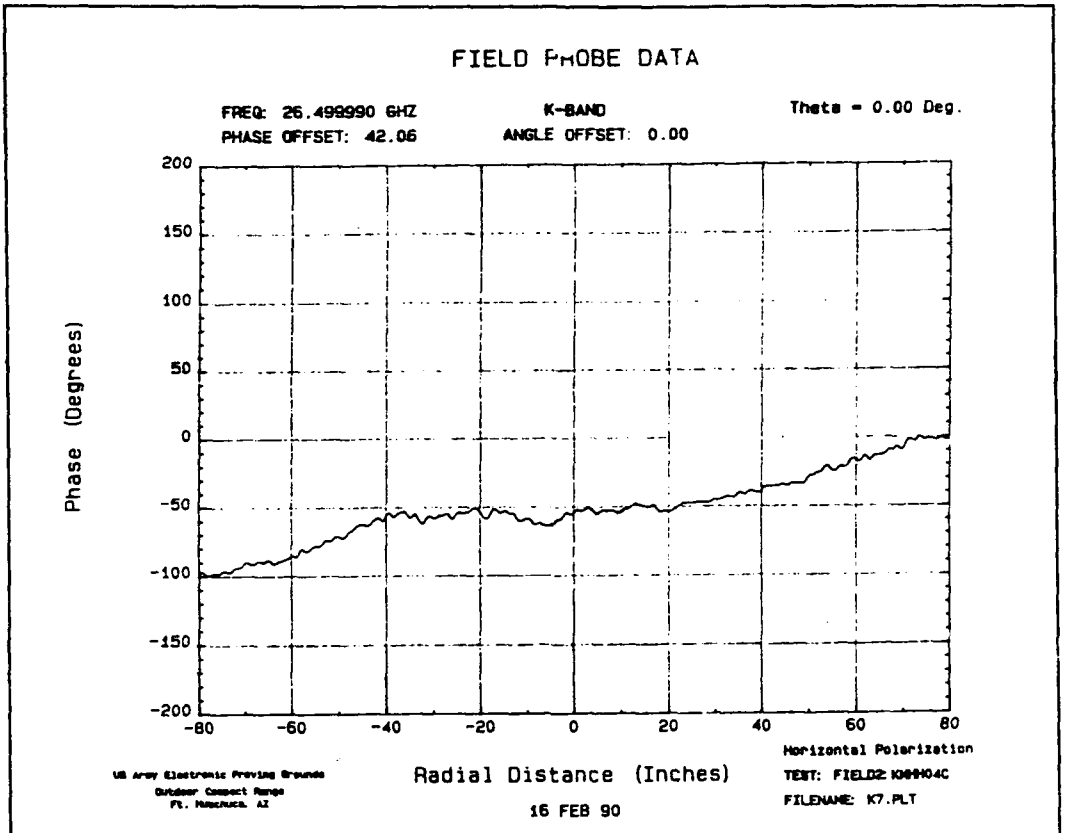

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 47.31
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 K048048
FILENAME: K7.PLT

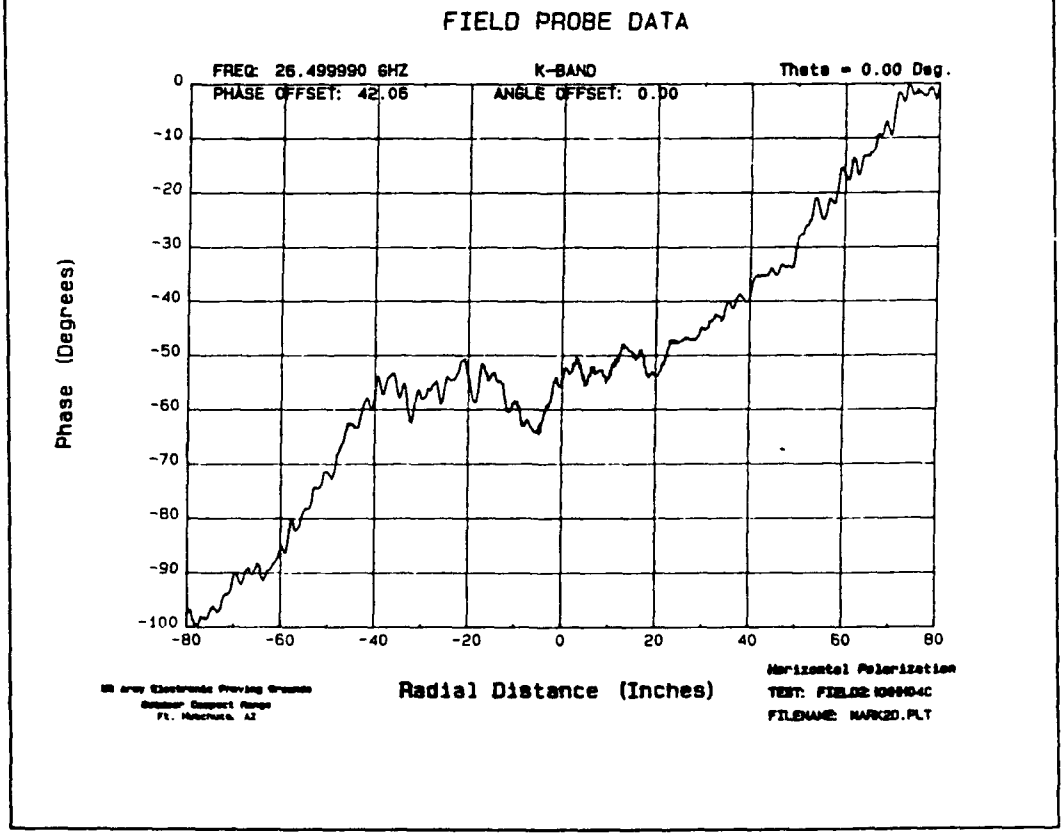

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 47.31
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2: K###04B
FILENAME: MARK2B.PLT
FIELD PI ,BE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 7.51
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2: K###04E
FILENAME: KAMP1.PLT
16-Feb-1990

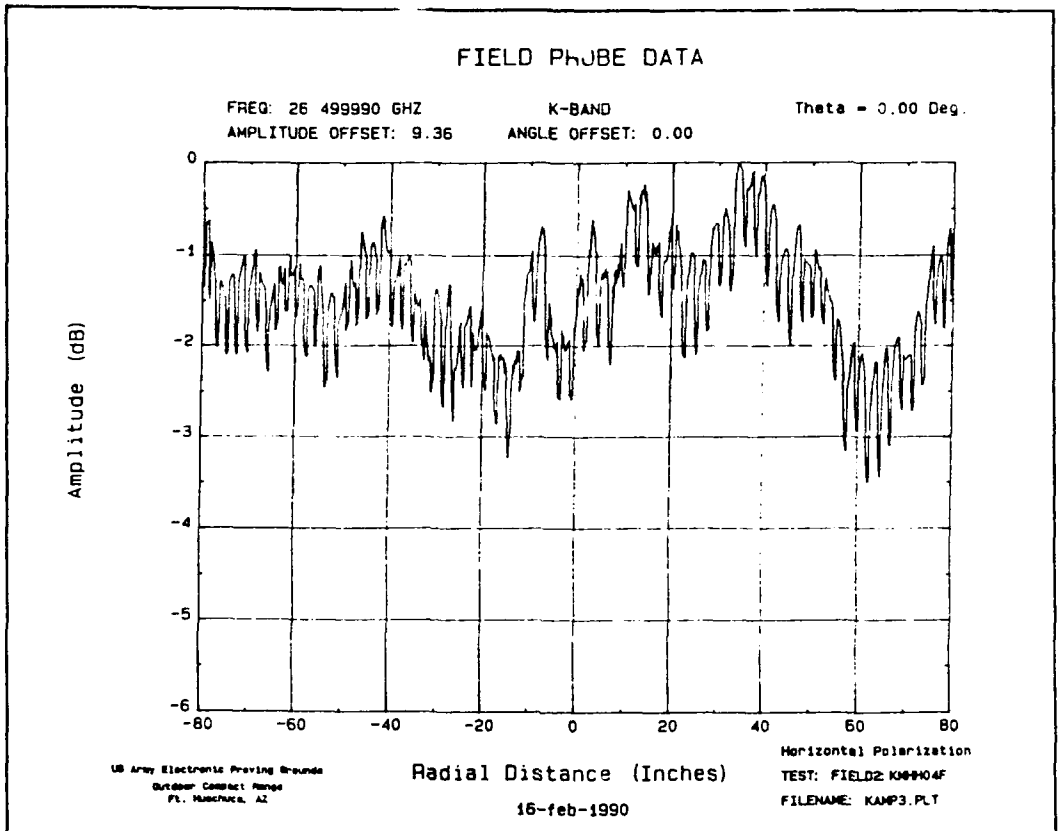

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -307.36
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 K0604E
FILENAME: K7.PLT
16 FEB 90

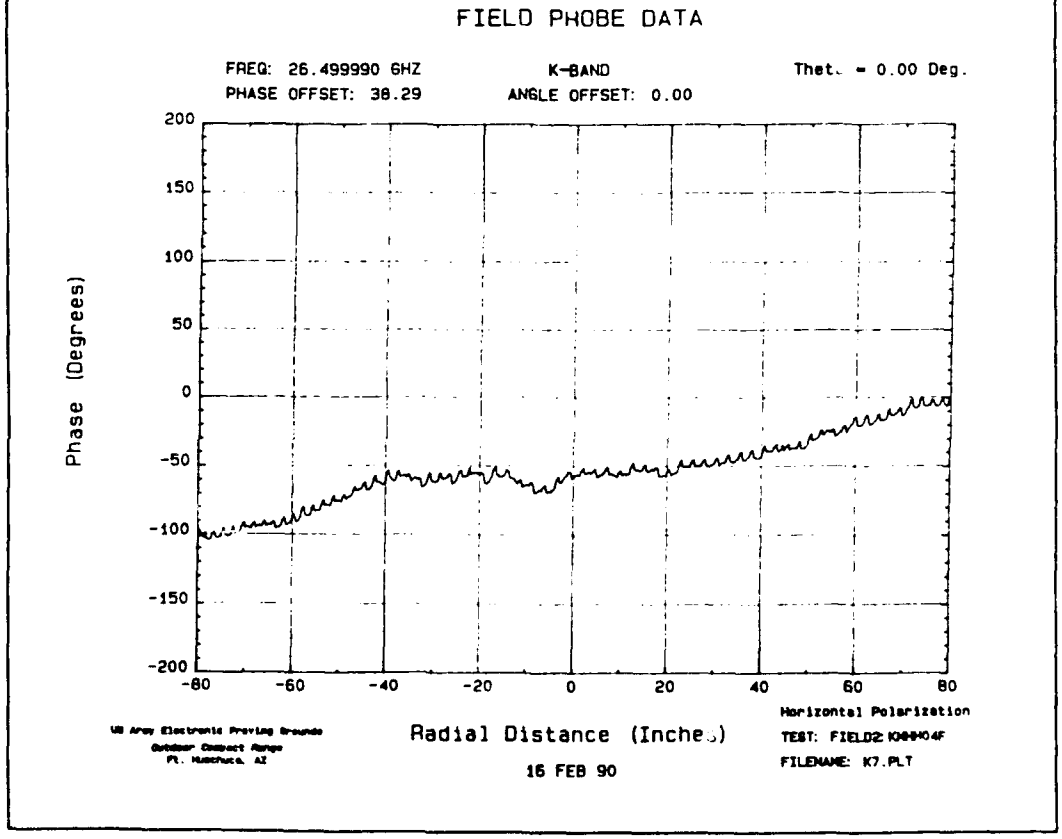

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -307.36
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-140
-160
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 K0604E
FILENAME: MARK2C.PLT

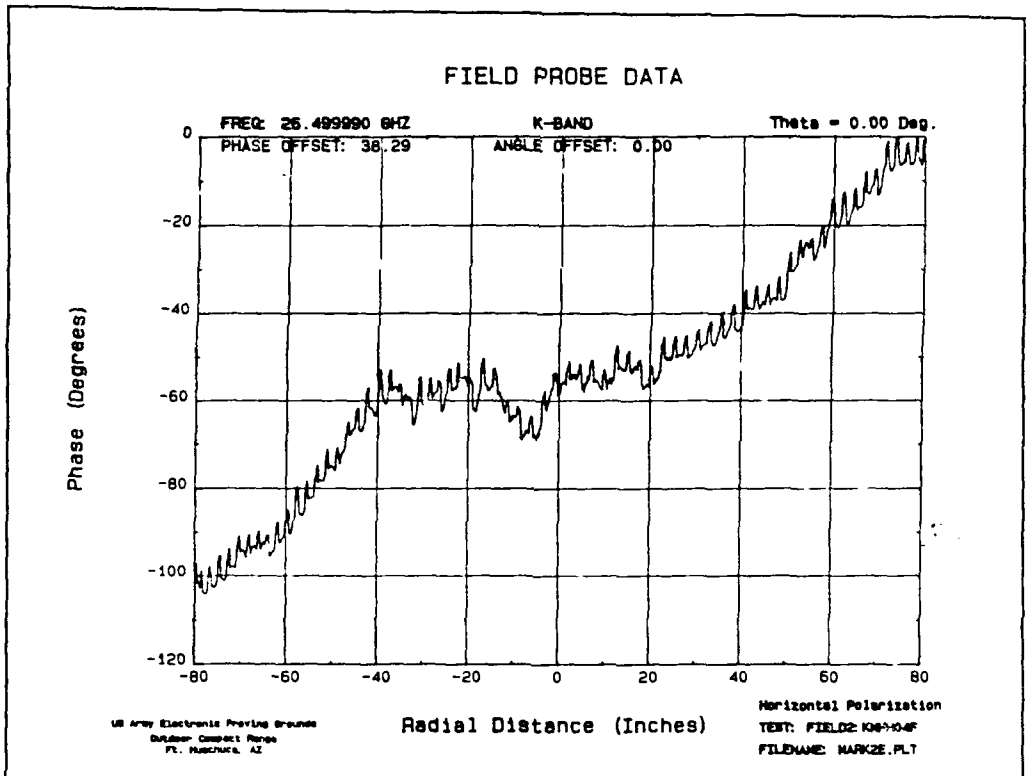

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -307.36
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 K##H04E
FILENAME: NARK2L.PLT
FIELD PROBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 9.65
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 K##H04C
FILENAME: KAMP1.PLT
16-Feb-1990

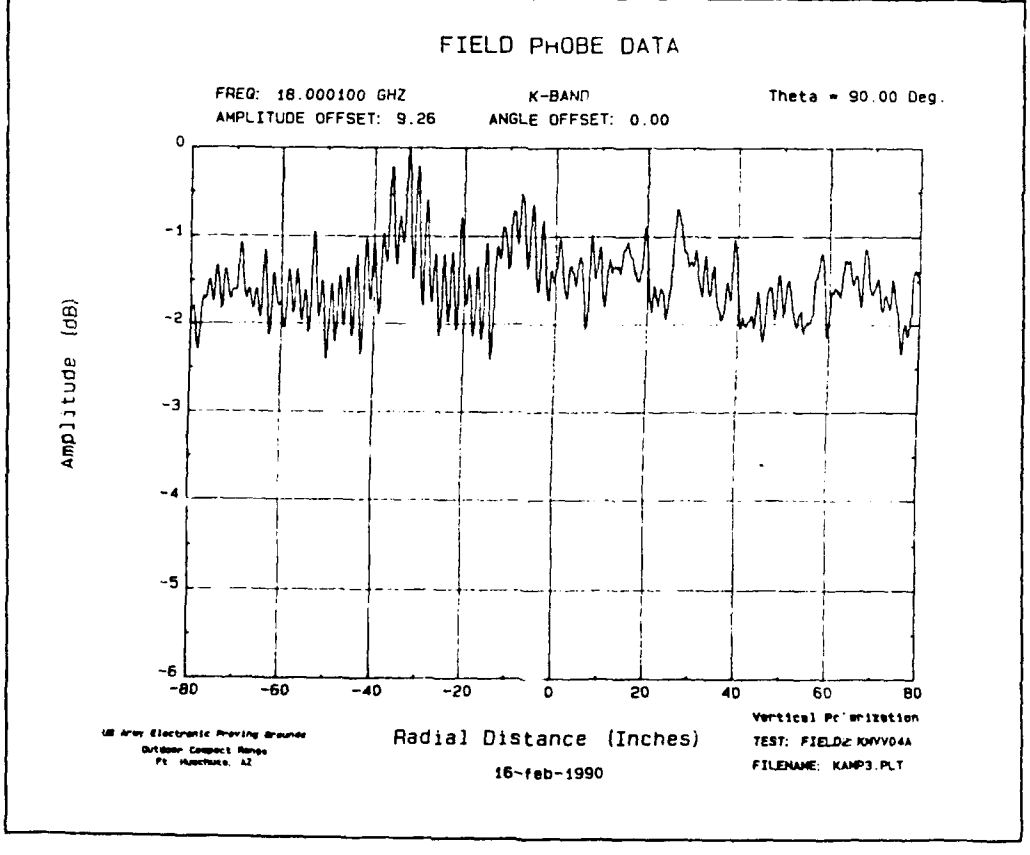

FIELD PROBE DATA
FREQ: 26.499990 GHZ
PHASE OFFSET: 42.06
K-BAND
ANGLE OFFSET: 0.00
Theta = 0.00 Deg.
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 KMHH04C
FILENAME: K7.PLT

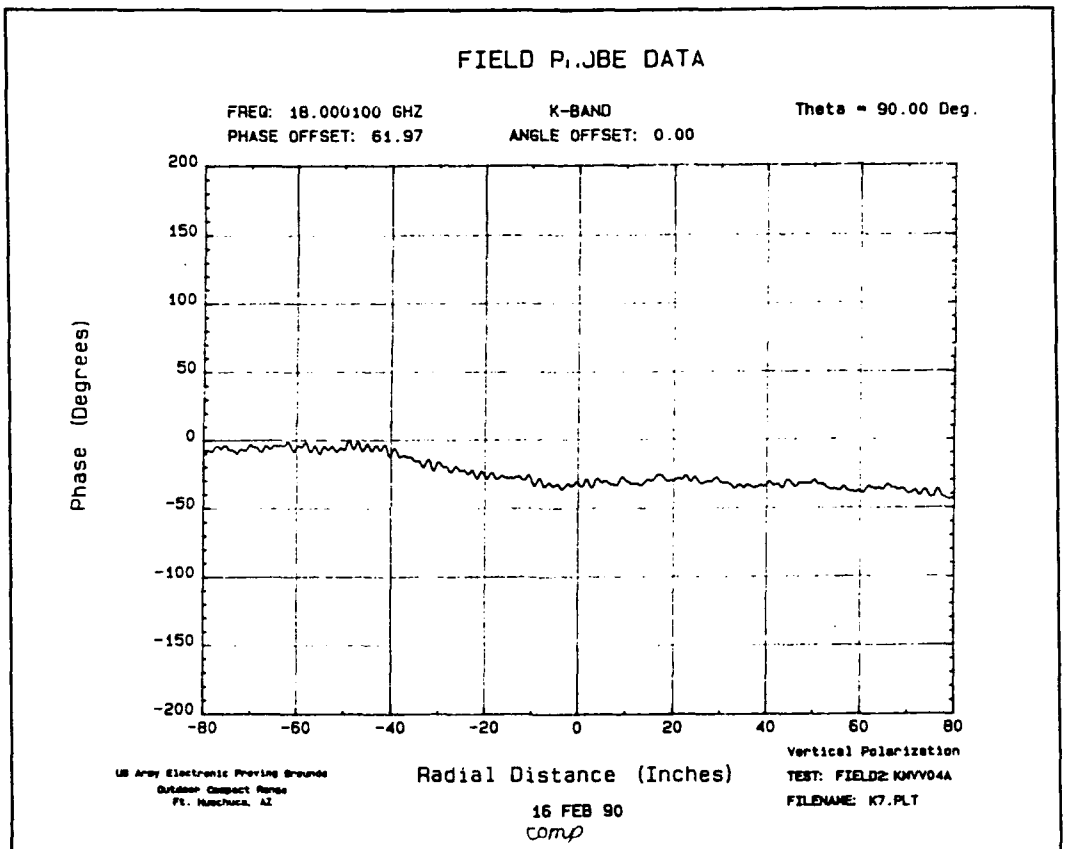

FIELD PROBE DATA
FREQ: 26.499990 GHZ
PHASE OFFSET: 42.06
K-BAND
ANGLE OFFSET: 0.00
Theta = 0.00 Deg.
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KMHH04C
FILENAME: MARK2D.PLT

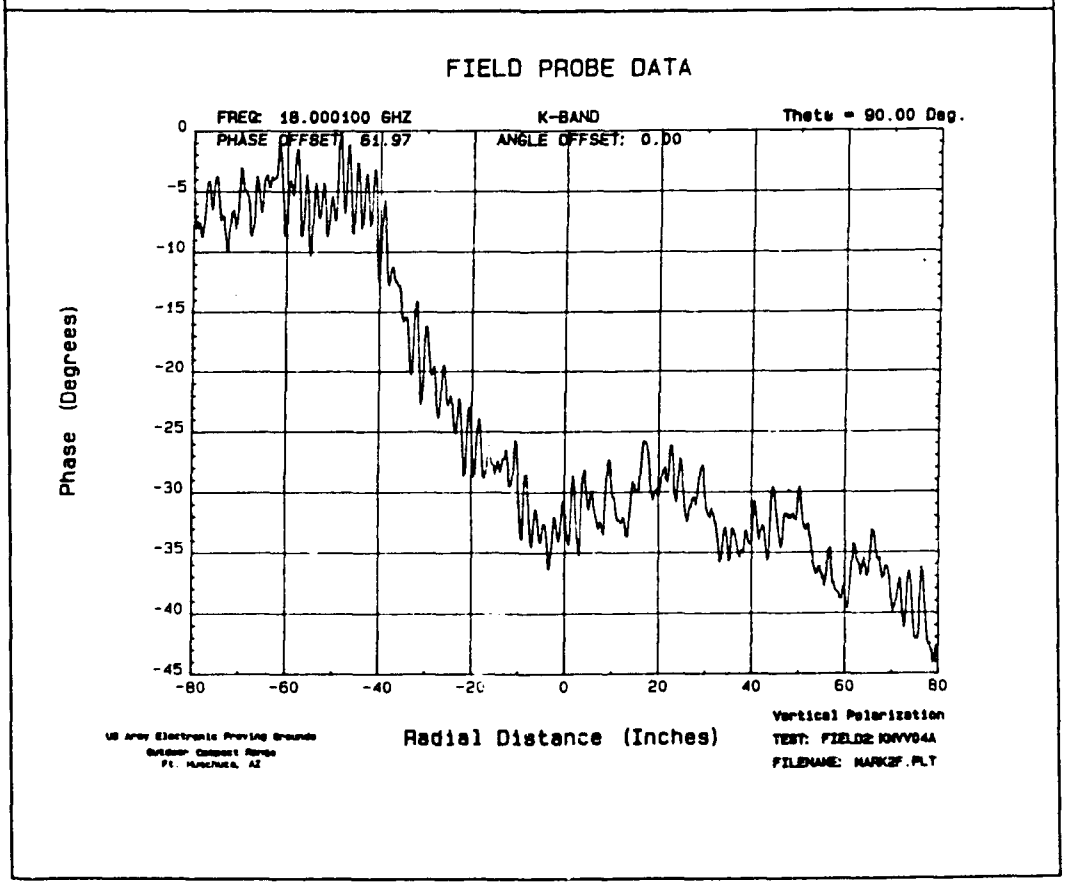

FIELD PROBE DATA
FREQ: 26 499990 GHZ
K-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 9.36
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16-feb-1990
Horizontal Polarization
TEST: FIELD2 K000104F
FILENAME: KAMP3.PLT

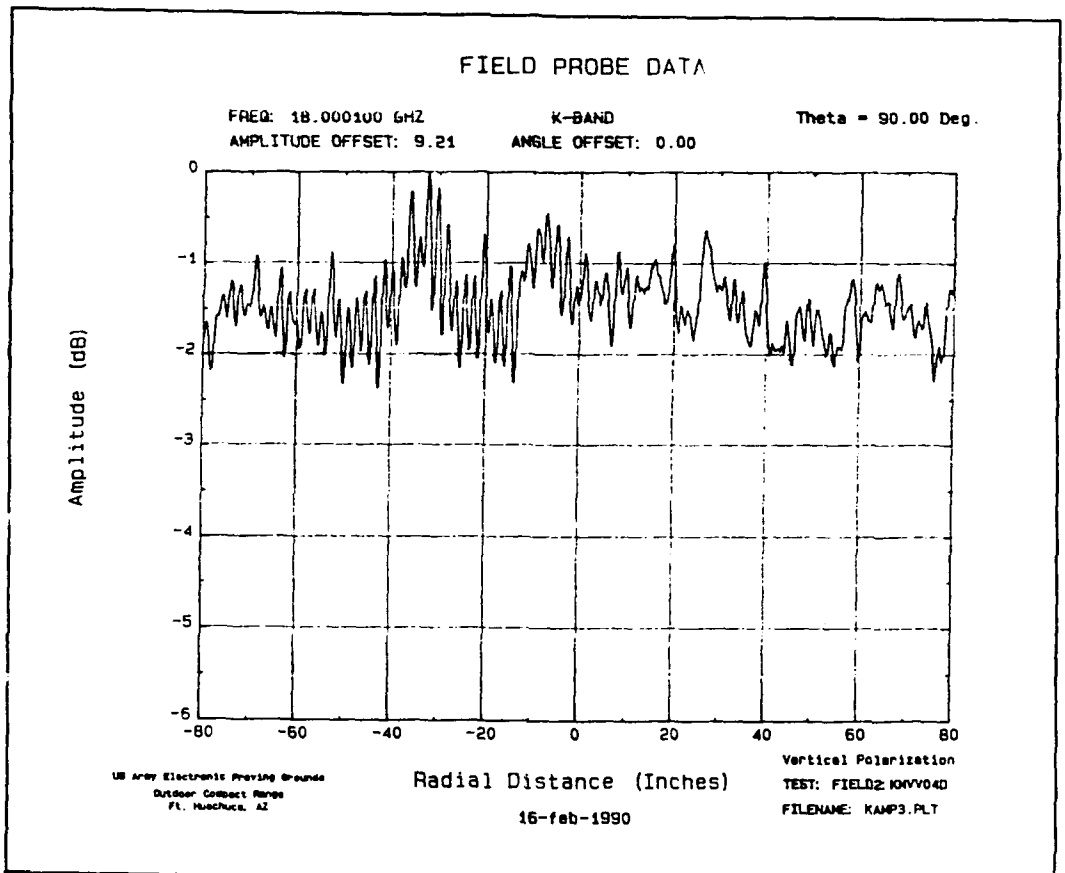

FIELD PROBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 38.29
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 K000104F
FILENAME: K7.PLT

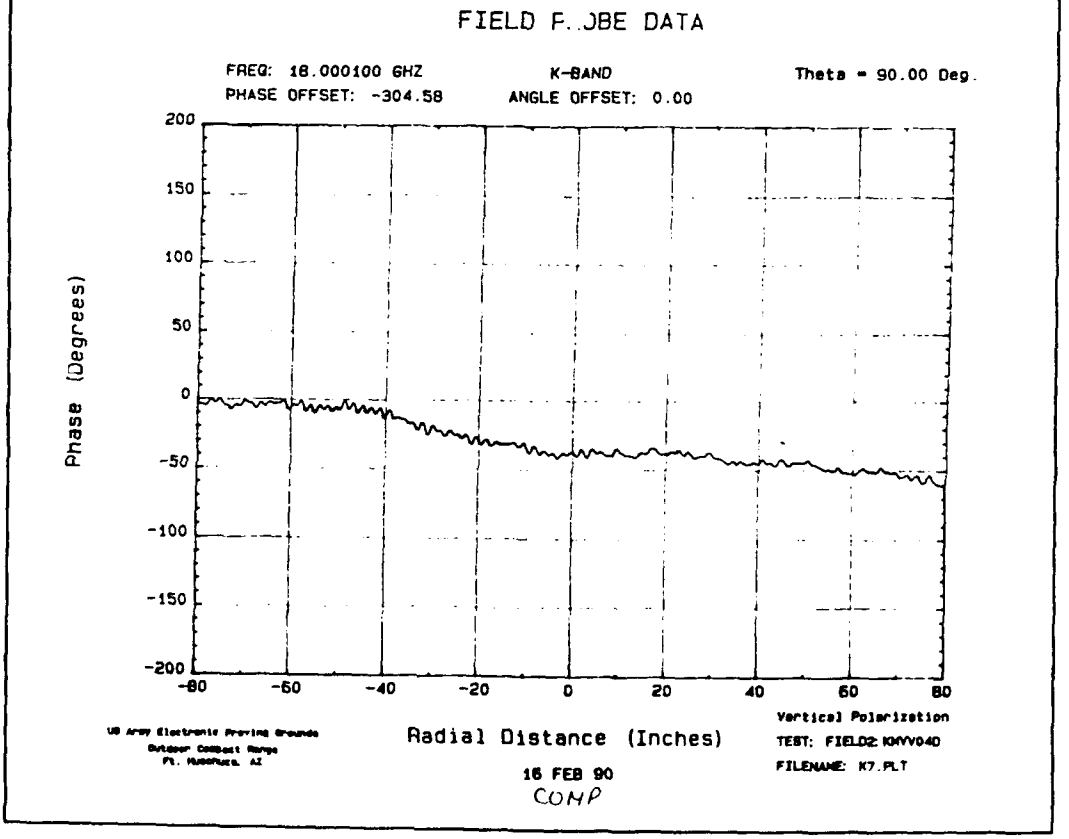

FIELD PROBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 38.29
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 K
FILENAME: MARK2E.PLT

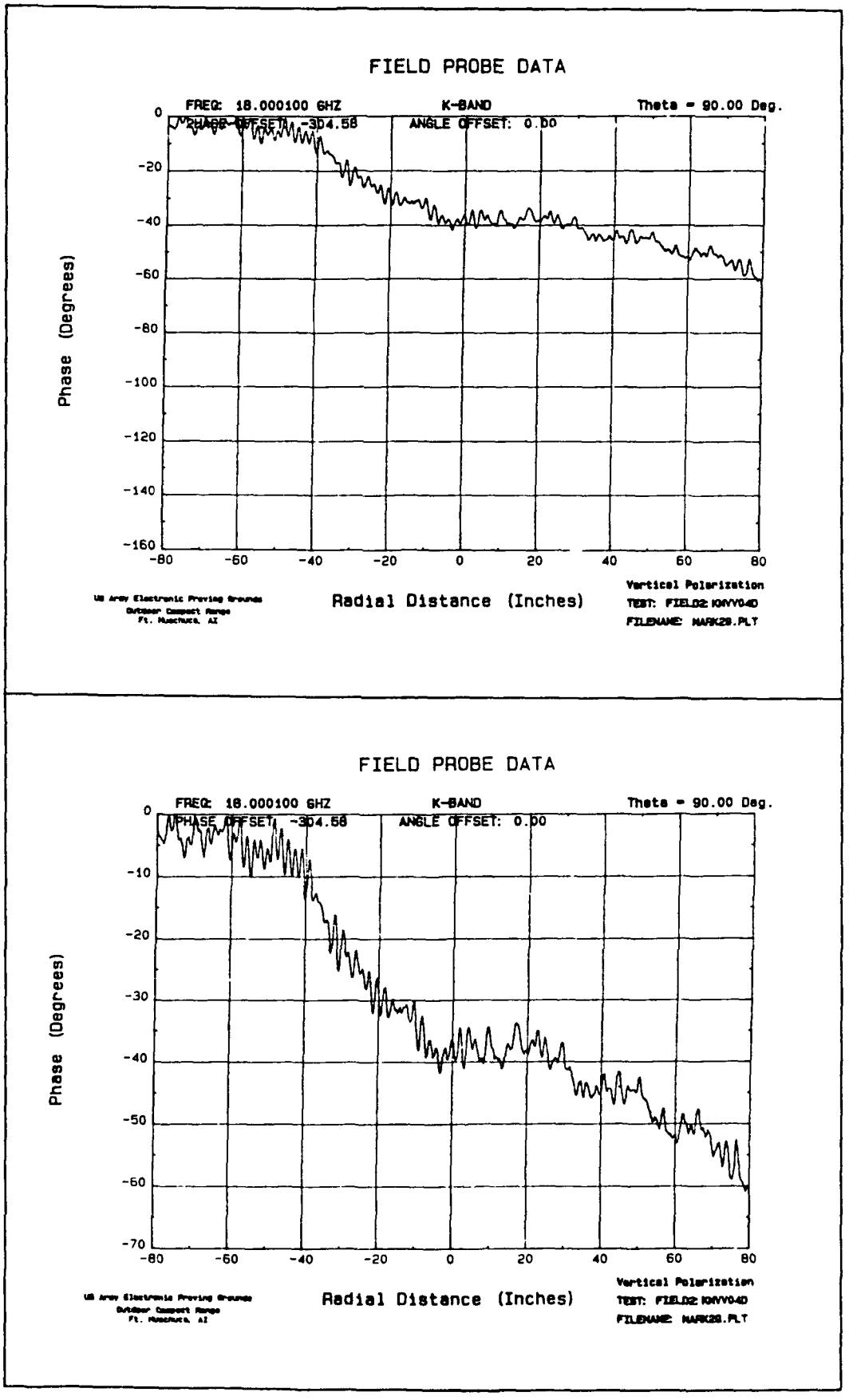

FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 9.26
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVV04A
FILENAME: KAMP3.PLT
16-feb-1990

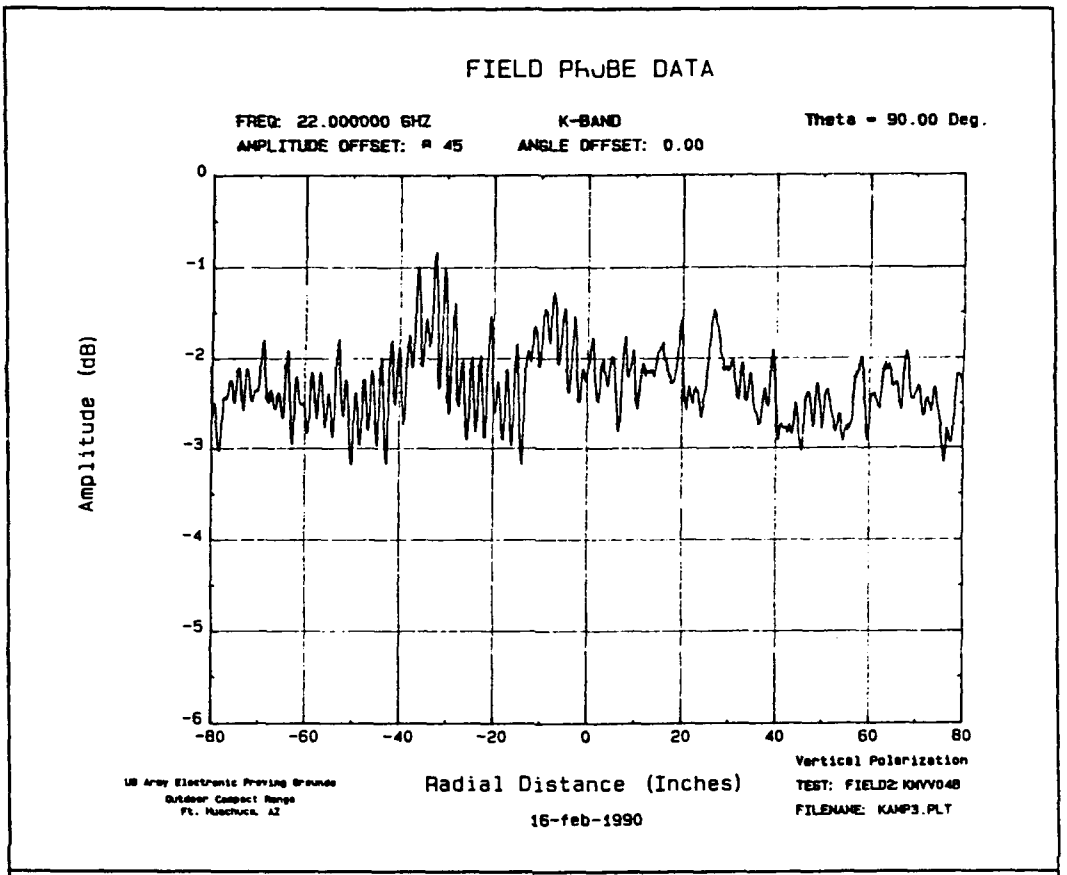

FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 61.97
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVV04A
FILENAME: K7.PLT
16 FEB 90
comp

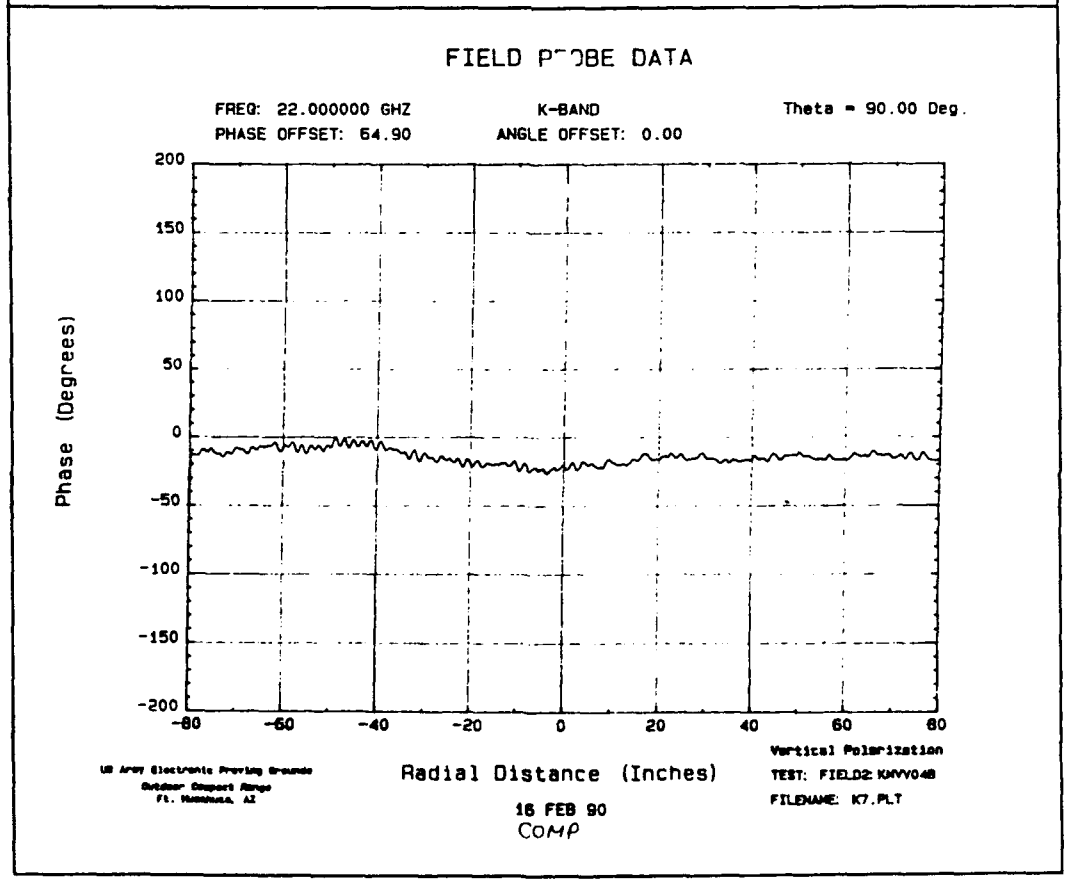

FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 61.97
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVV04A
FILENAME: MARK2F.PLT

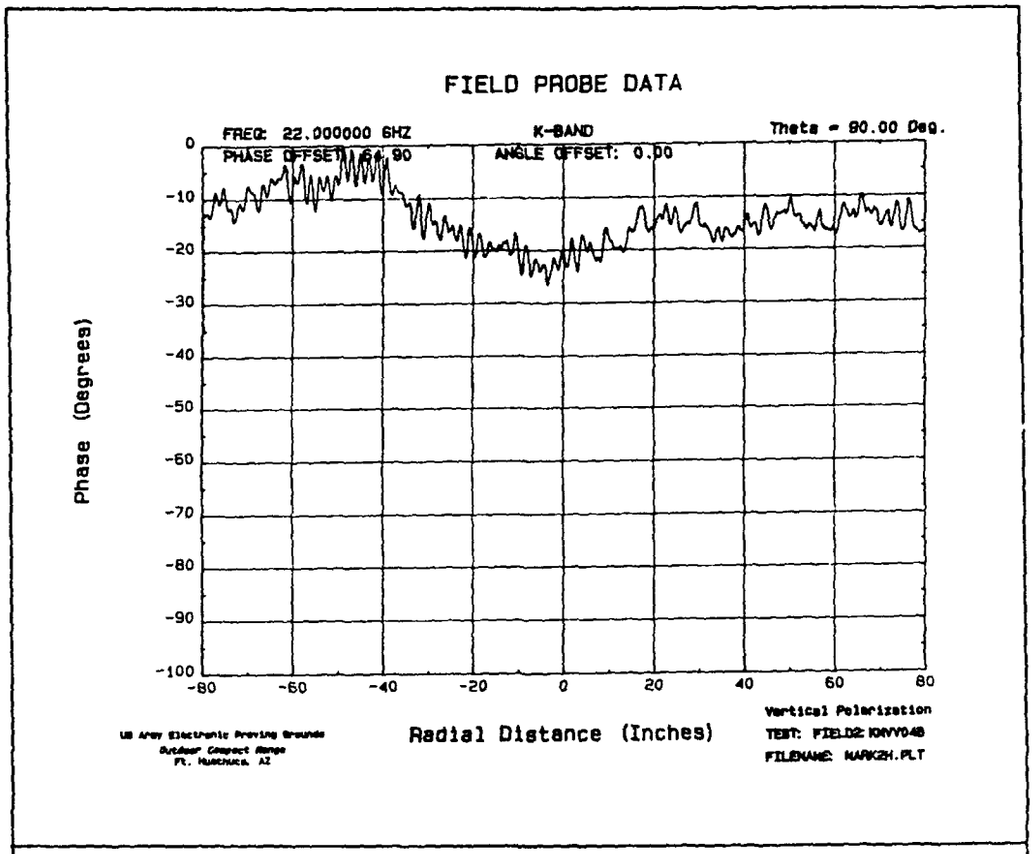

FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 9.21
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVV040
FILENAME: KAMP3.PLT
16-feb-1990

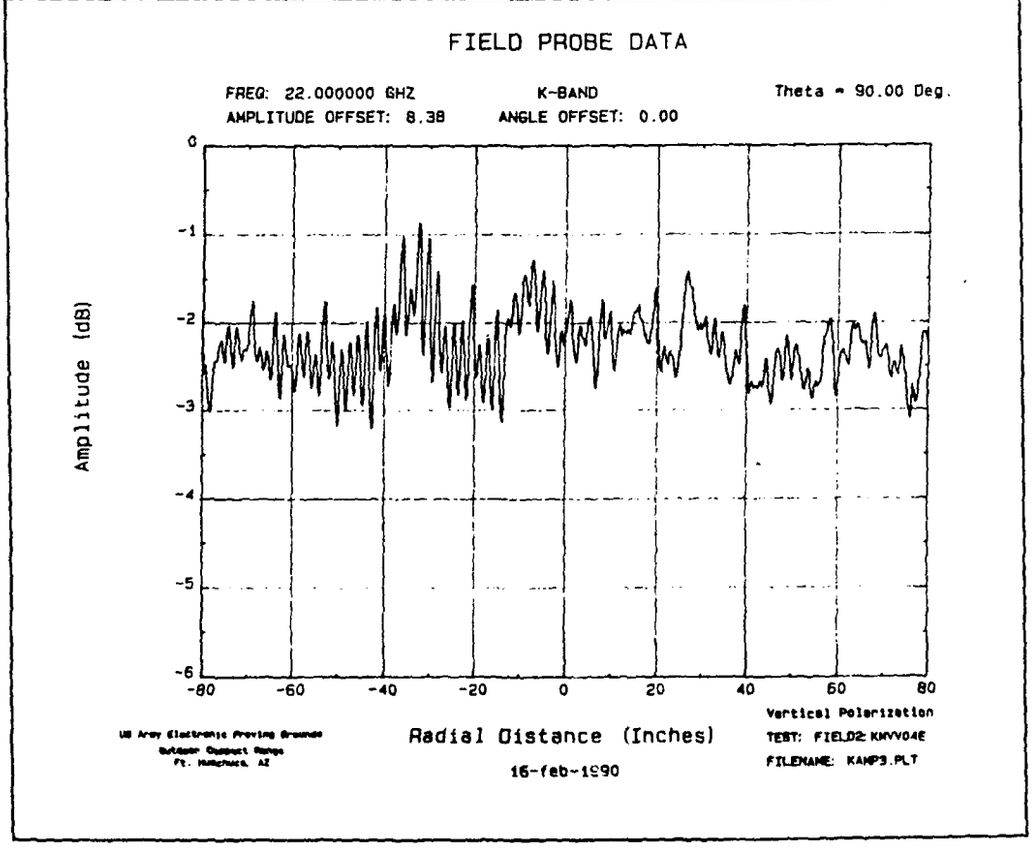

FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -304.58
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVV040
FILENAME: K7.PLT
16 FEB 90
COMP

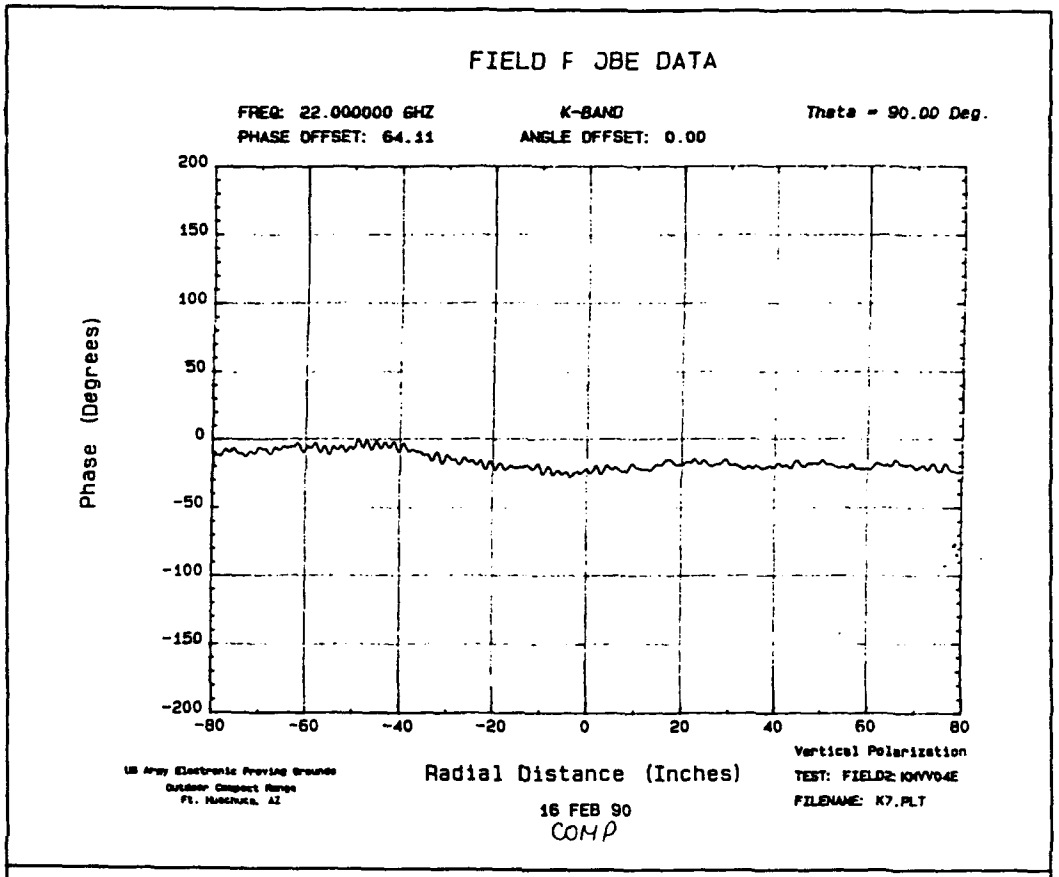

FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -304.58
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-140
-160
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2 KHVV040
FILENAME: MARK28.PLT
FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -304.58
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2 KHVV040
FILENAME: MARK28.PLT

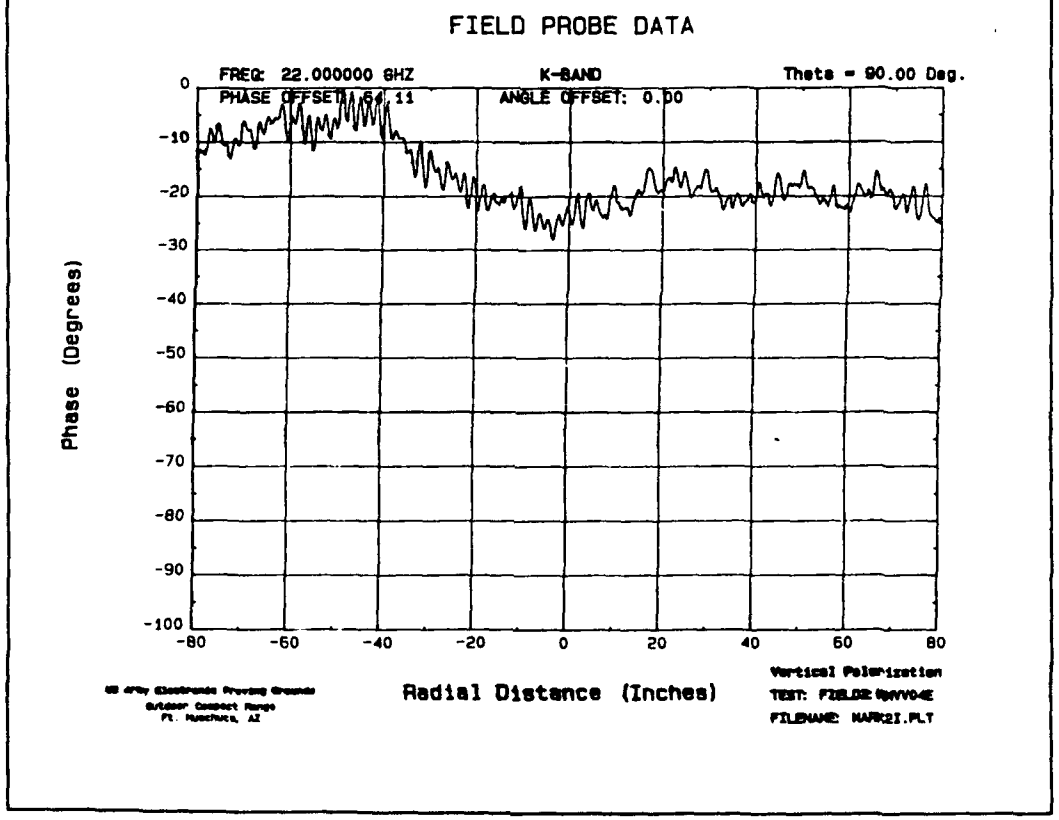

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 8.45
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KMVV04B
FILENAME: KAMP3.PLT
16-feb-1990

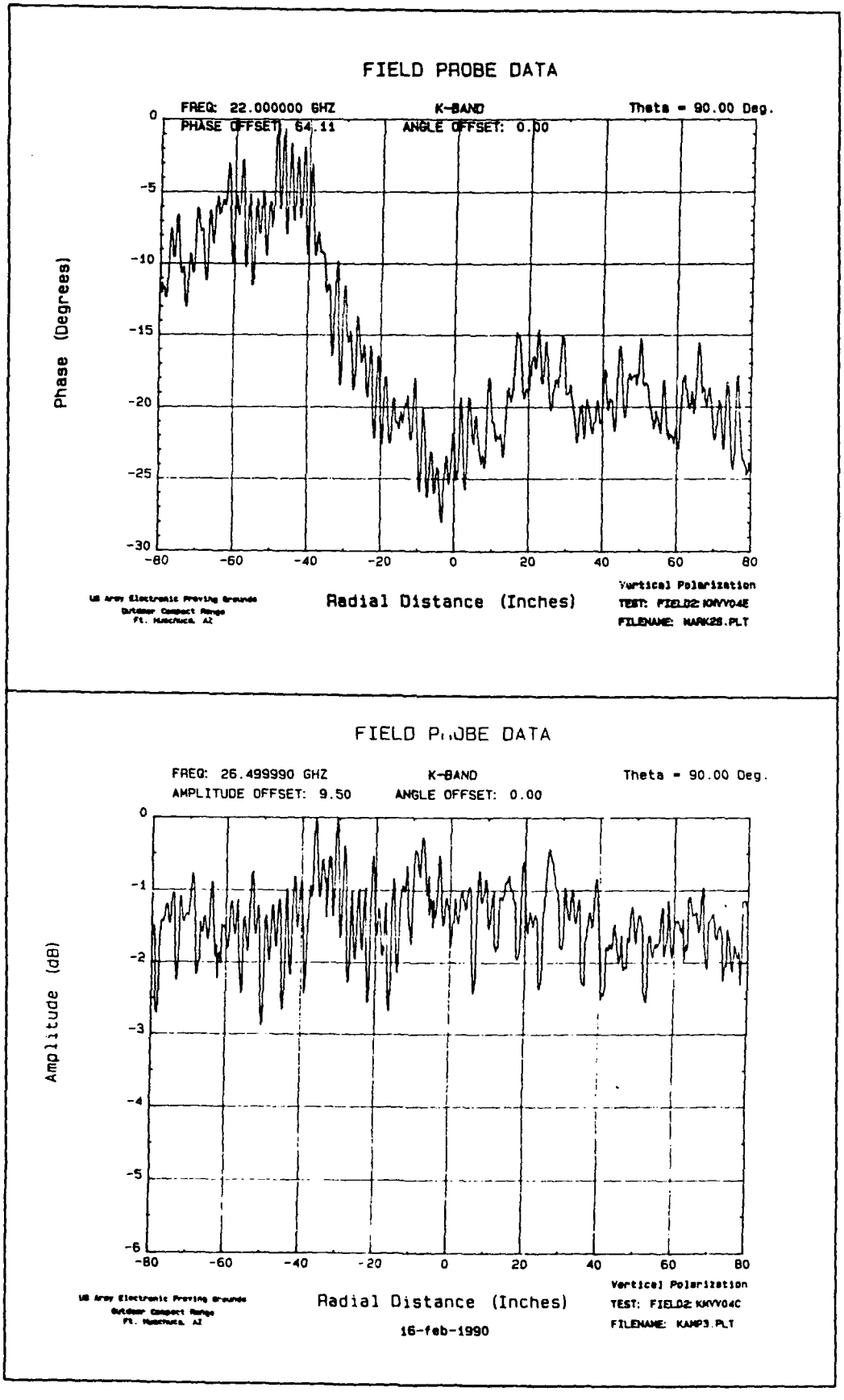

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 64.90
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KMVV04B
FILENAME: K7.PLT
16 FEB 90
COMP

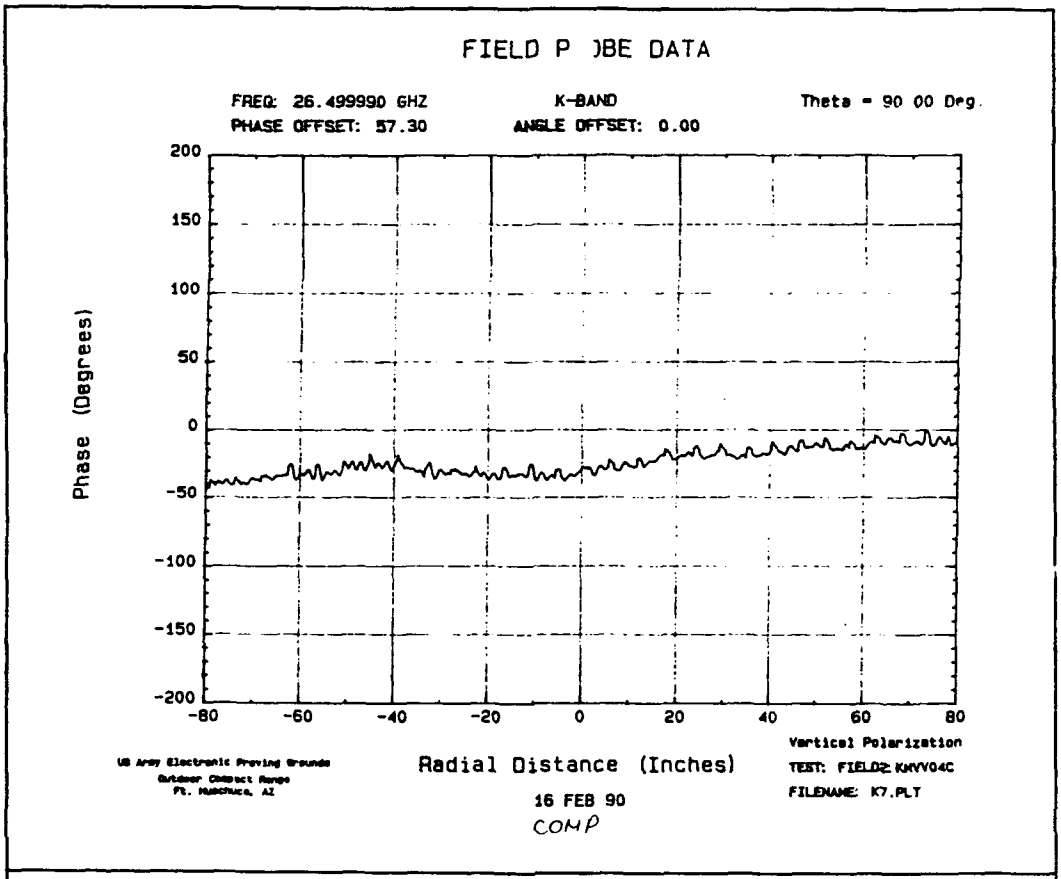

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 61.90
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVV04B
FILENAME: HARK2H.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ

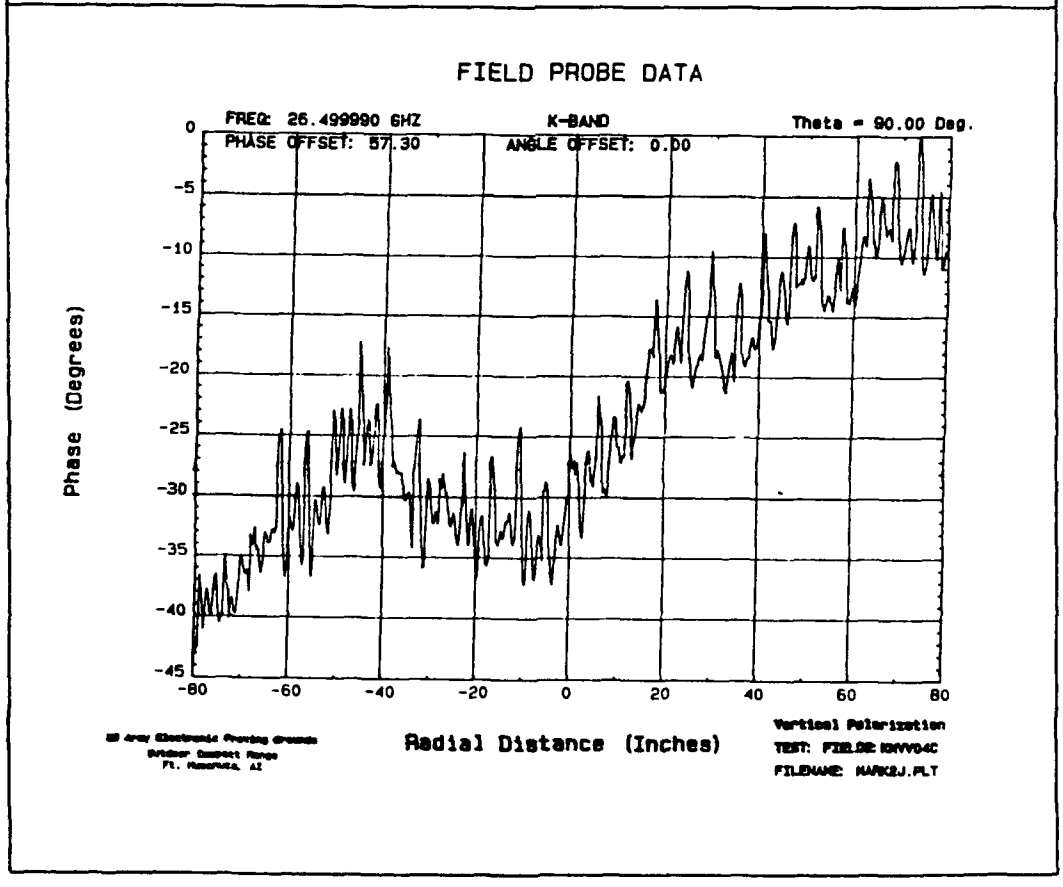

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 8.38
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVV04E
FILENAME: KAMP3.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
16-feb-1990

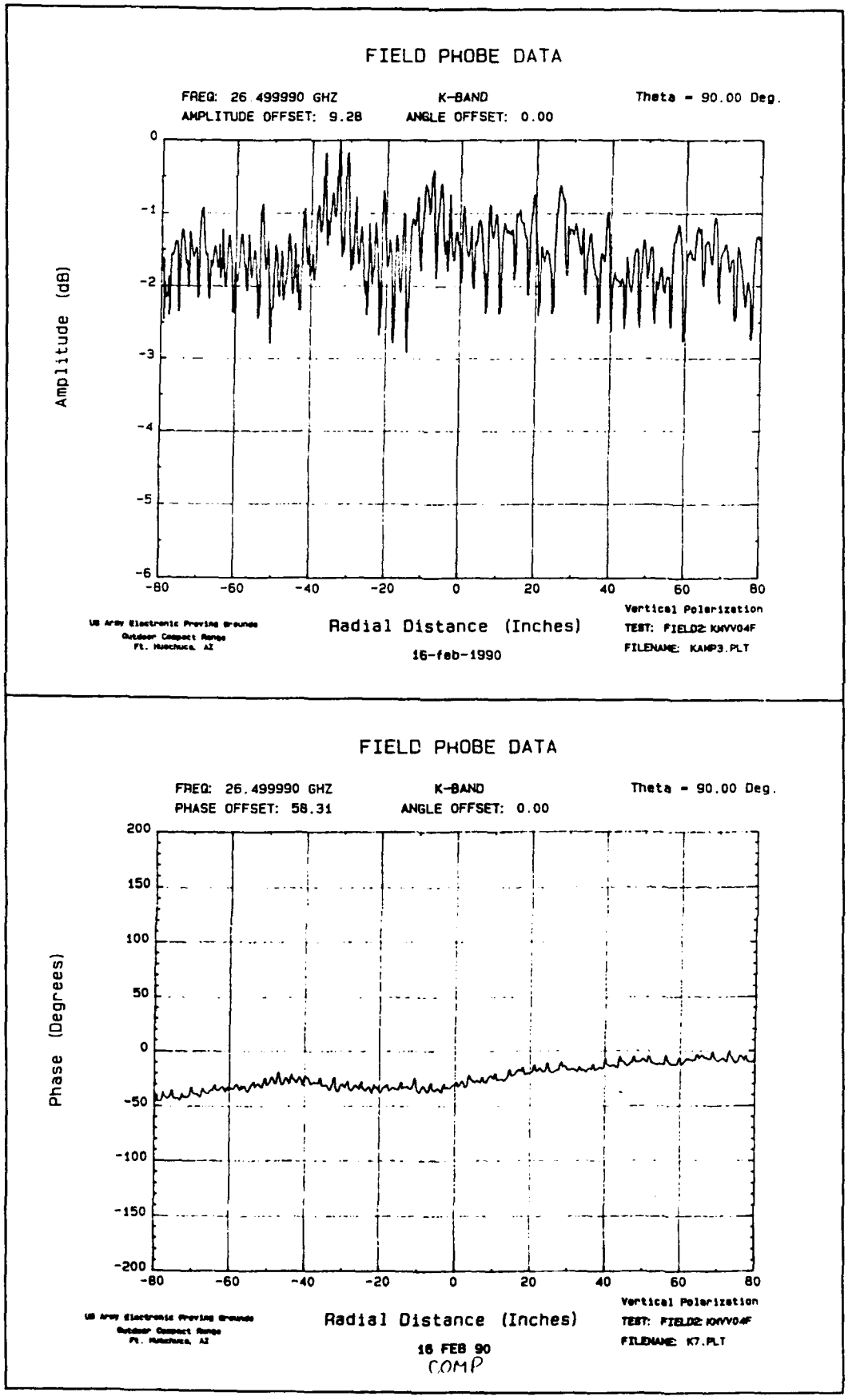

FIELD F JBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 64.11
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2: KHVV04E
FILENAME: K7.PLT
16 FEB 90
COMP

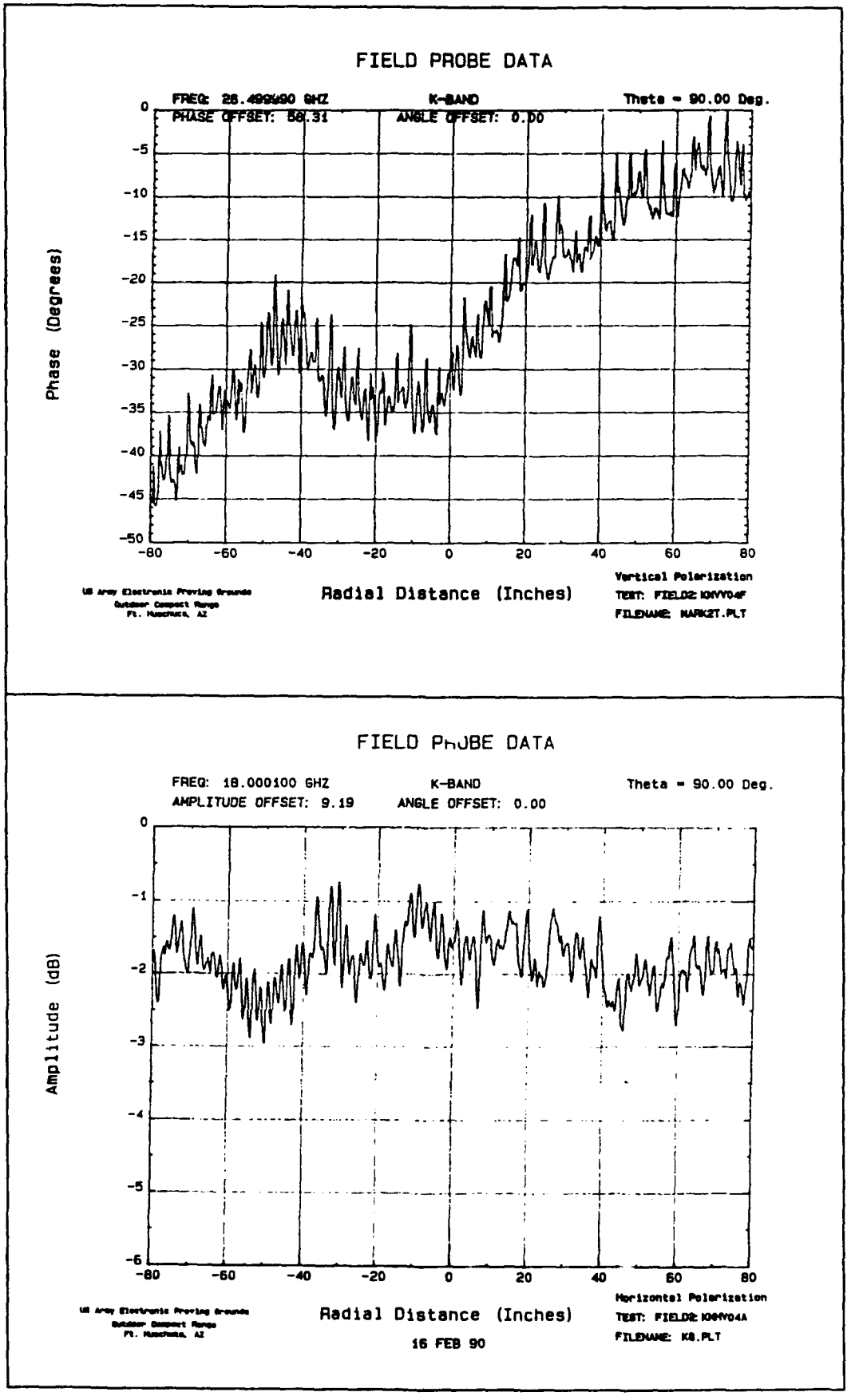

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 64.11
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
FILENAME: MARK2I.PLT

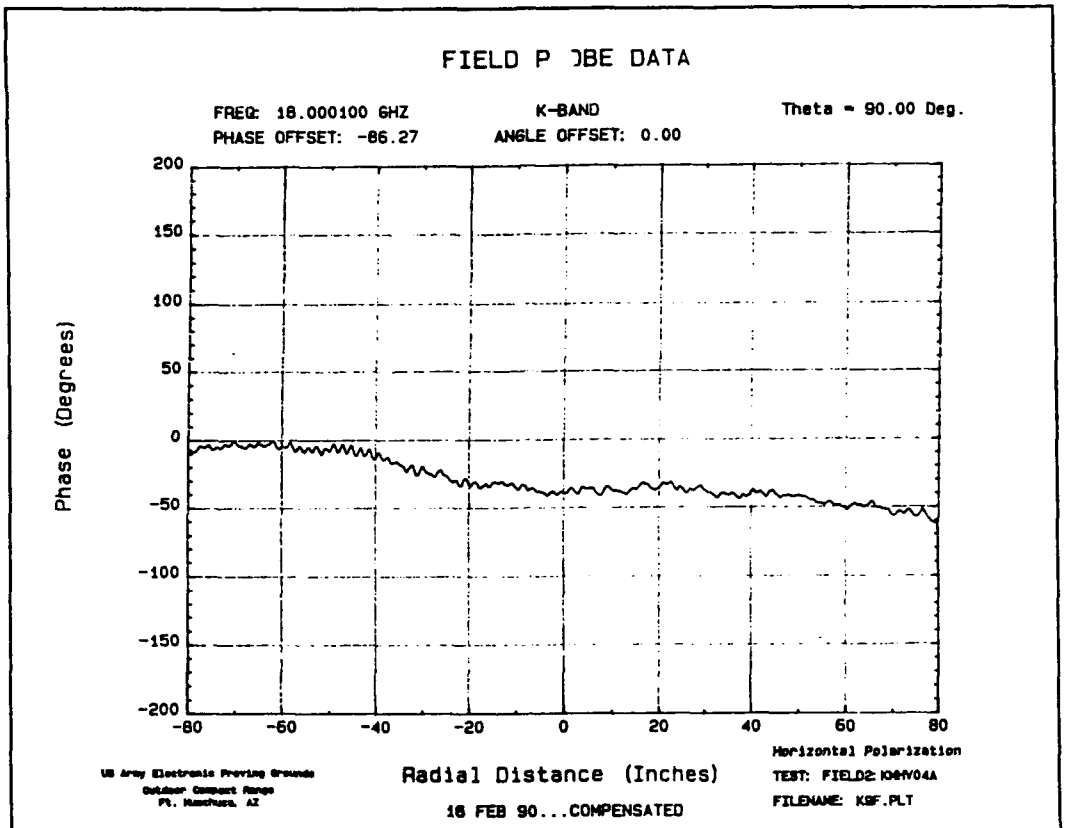

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 64.11
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2 KHVV04E
FILENAME: MARK2S.PLT
FIELD PROBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 9.50
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
16-feb-1990
Vertical Polarization
TEST: FIELD2 KHVV04C
FILENAME: KAMP3.PLT

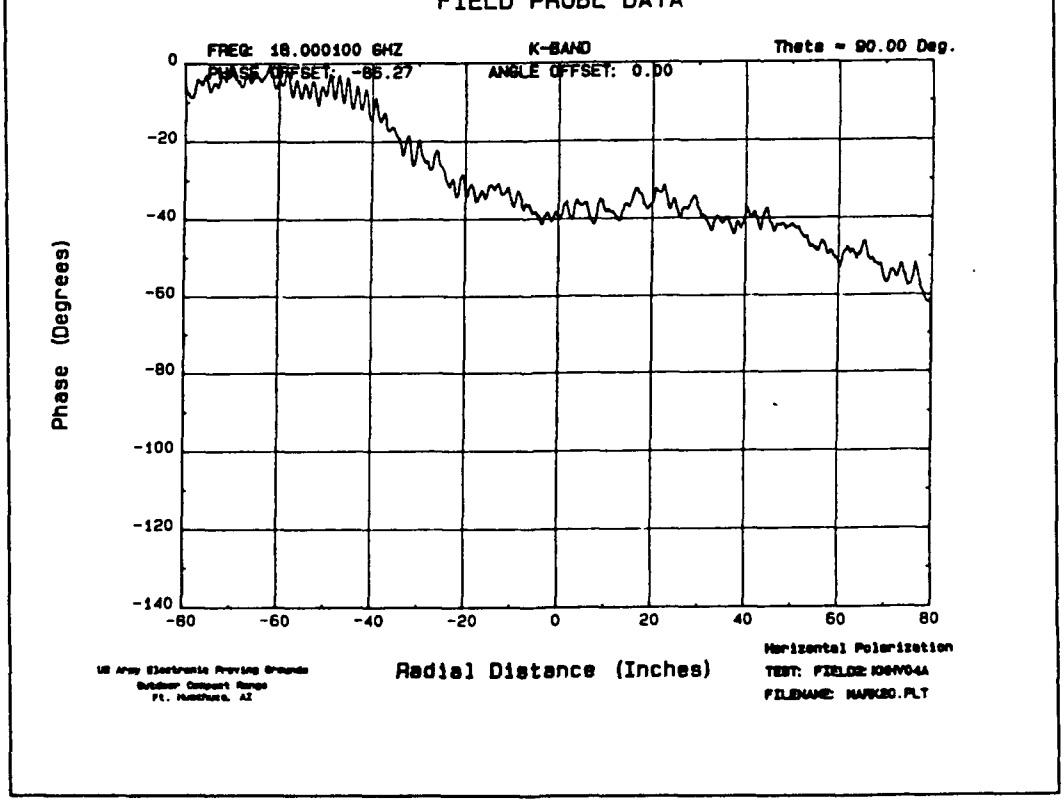

FIELD P)BE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 90 00 Deg.
PHASE OFFSET: 57.30
ANGLE OFFSET: 0.00
200
150
100
50
0
-50
-100
-150
-200
Phase (Degrees)
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KHVV04C
FILENAME: K7.PLT
16 FEB 90
COMP

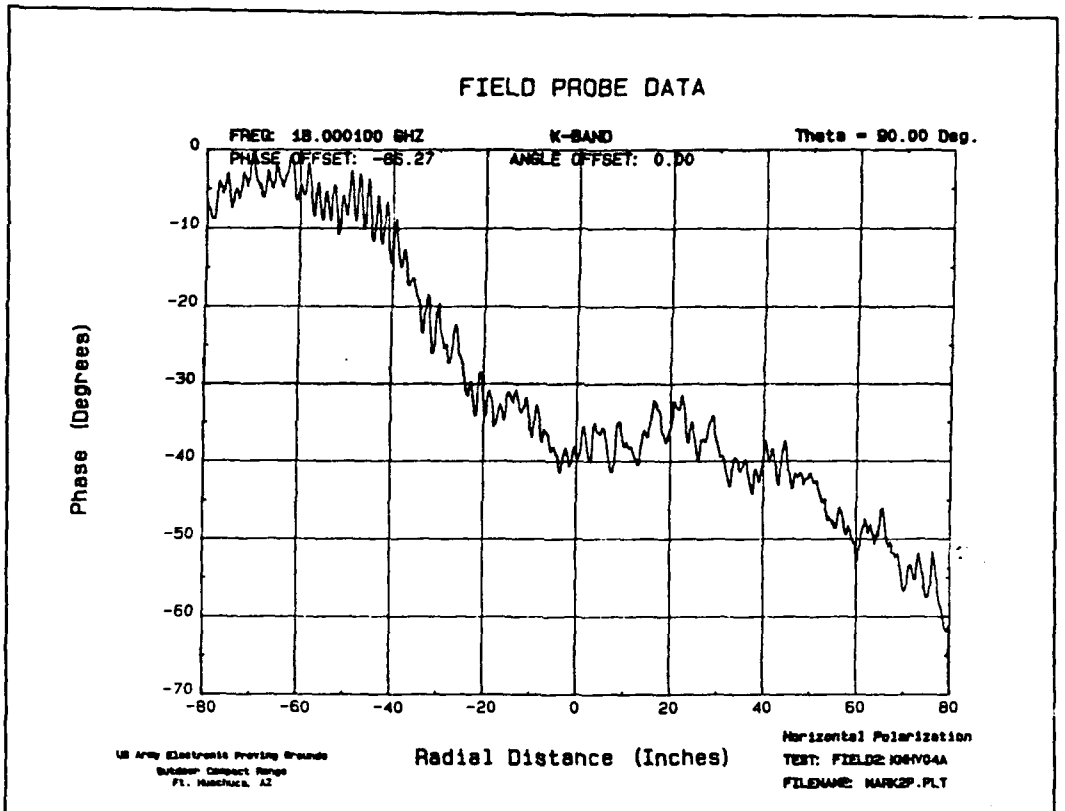

FIELD PROBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 57.30
ANGLE OFFSET: 0.00
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Phase (Degrees)
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
FILENAME: MARK2J.PLT

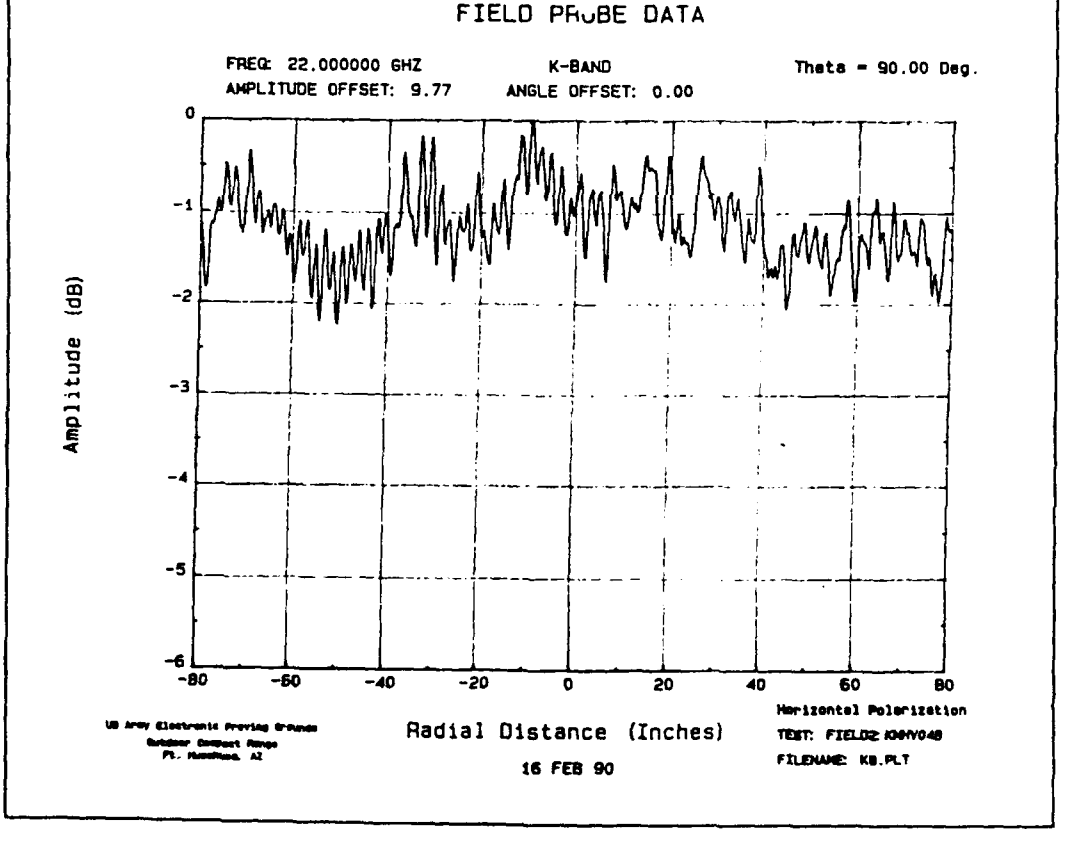

FIELD PHOBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 9.28
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16-feb-1990
Vertical Polarization
TEST: FIELD2 KMVV04F
FILENAME: KAMP3.PLT
FIELD PHOBE DATA
FREQ: 26.499990 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 58.31
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
COMP
Vertical Polarization
TEST: FIELD2 KMVV04F
FILENAME: K7.PLT

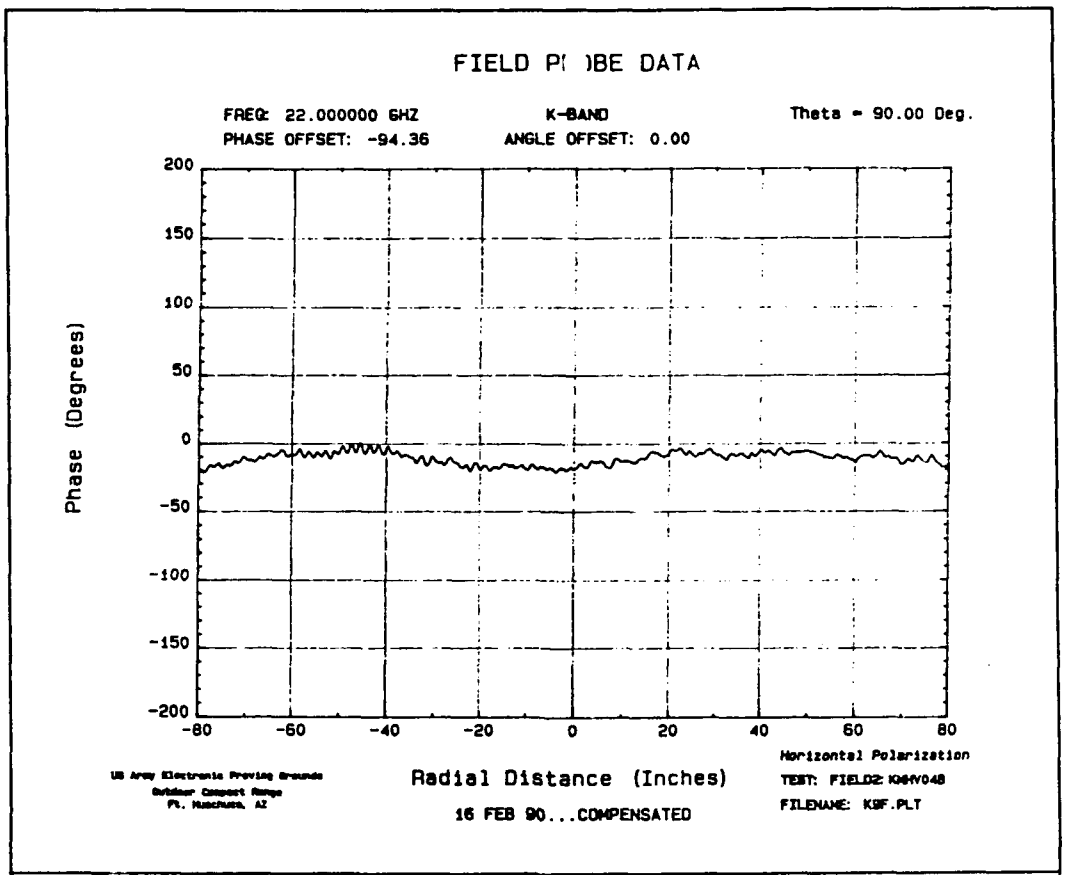

FIELD PROBE DATA
FREQ: 28.499490 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 58.31
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2 K04VV04F
FILENAME: MARK2T.PLT
FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 9.19
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 K04VV04A
FILENAME: K8.PLT
16 FEB 90

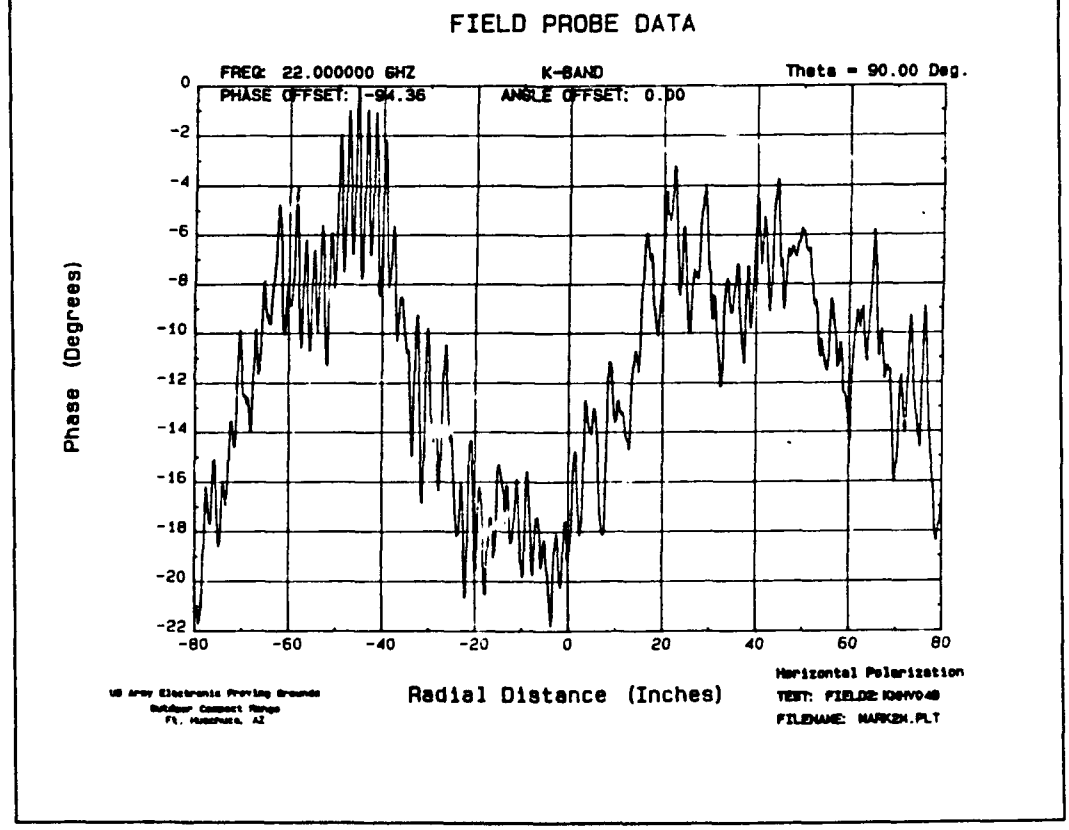

FIELD P OBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -86.27
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90...COMPENSATED
Horizontal Polarization
TEST: FIELD2 K64V04A
FILENAME: K8F.PLT

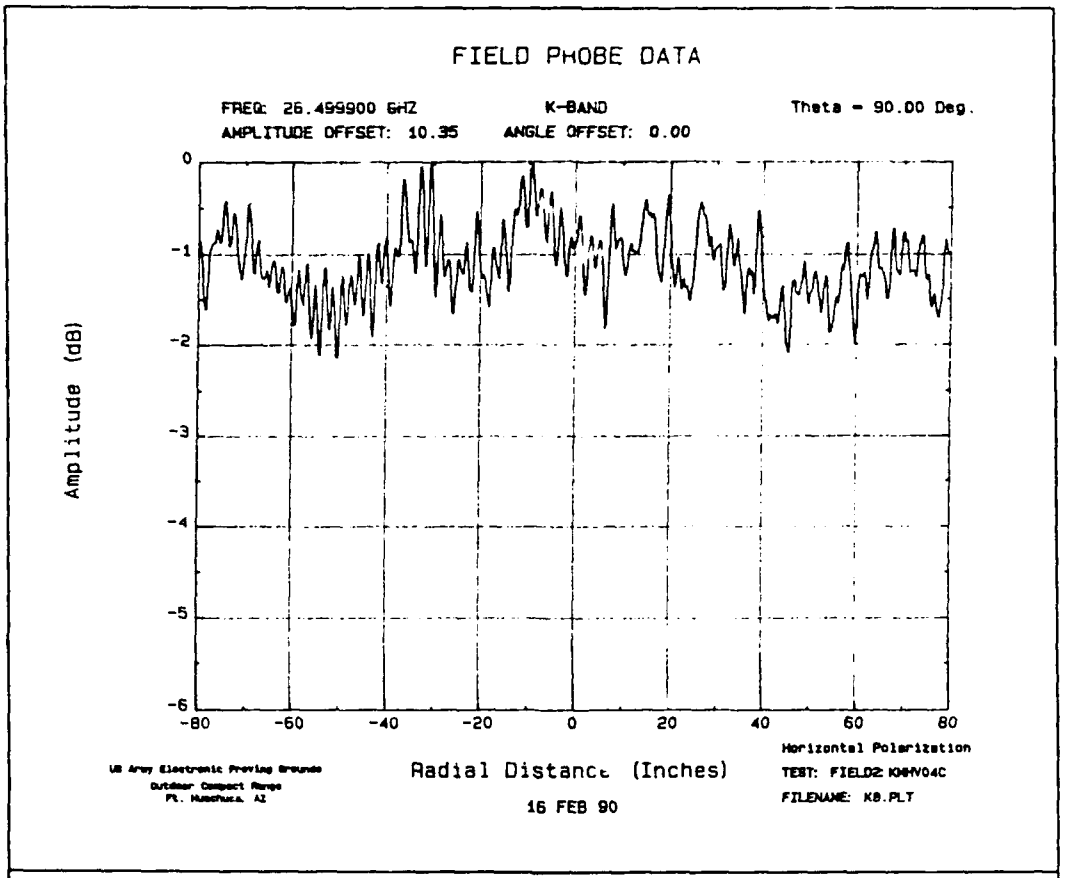

FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -86.27
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-140
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 K64V04A
FILENAME: MAPK80.PLT

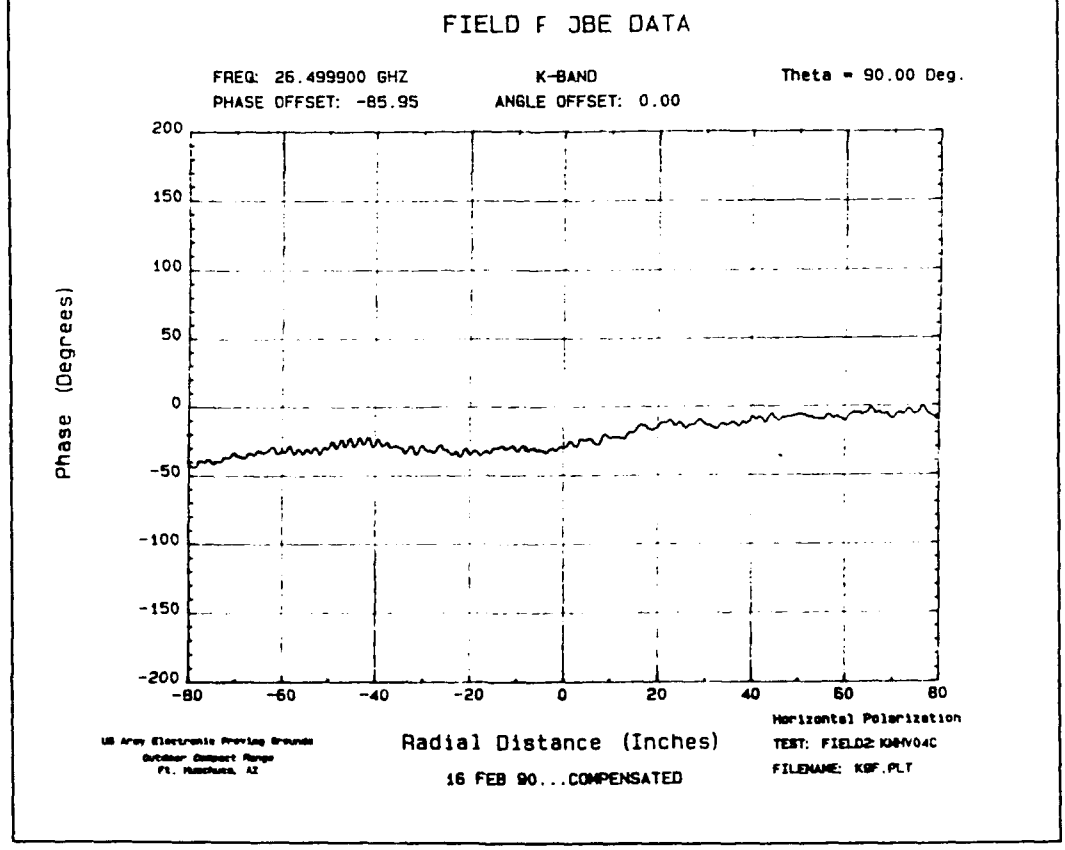

FIELD PROBE DATA
FREQ: 18.000100 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -85.27
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 K96V04A
FILENAME: MARK2P.PLT

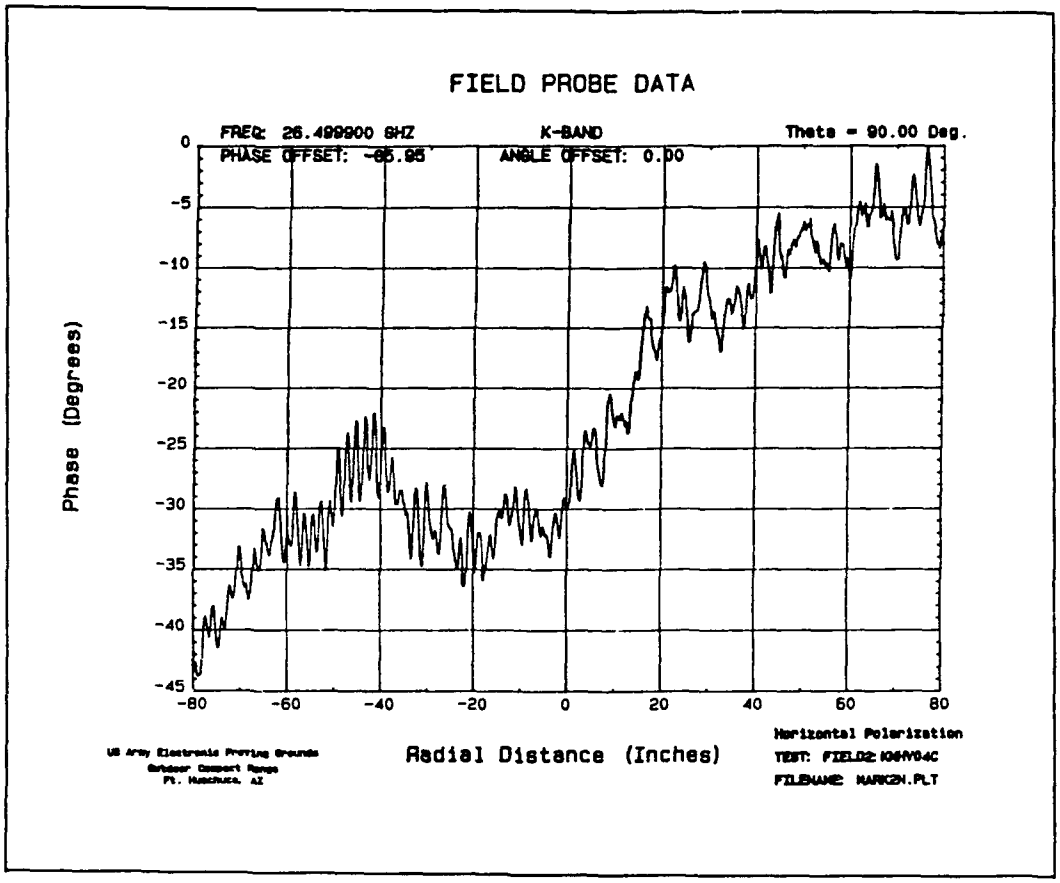

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 9.77
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 K96V04B
FILENAME: KB.PLT
16 FEB 90

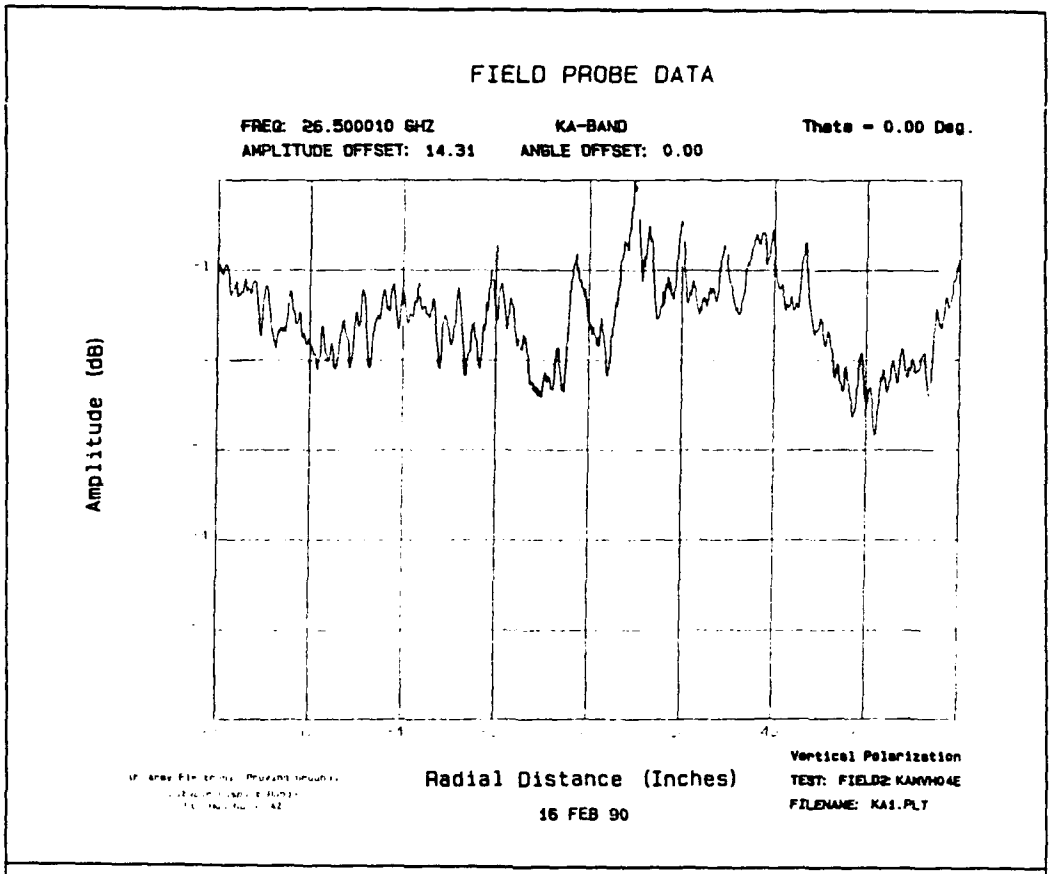

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -94.36
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90...COMPENSATED
Horizontal Polarization
TEST: FIELD2: K96V048
FILENAME: K8F.PLT

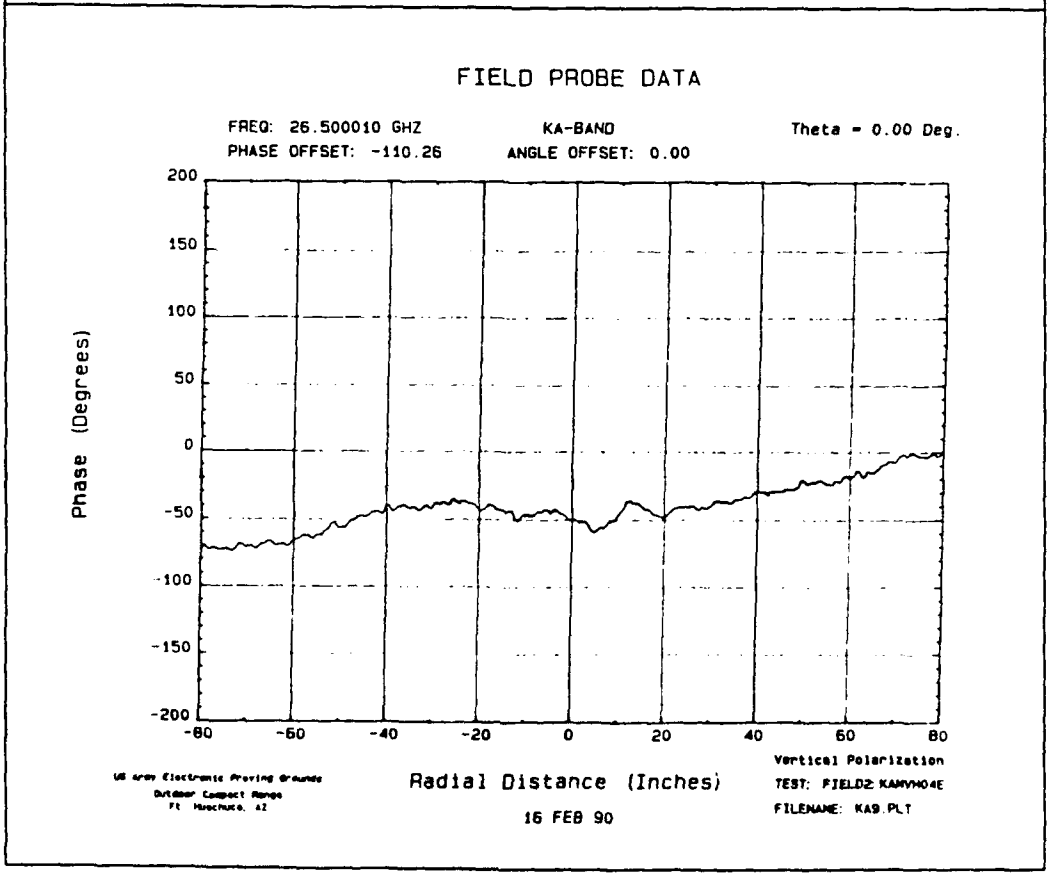

FIELD PROBE DATA
FREQ: 22.000000 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -94.36
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2: K96V048
FILENAME: MARK2H.PLT

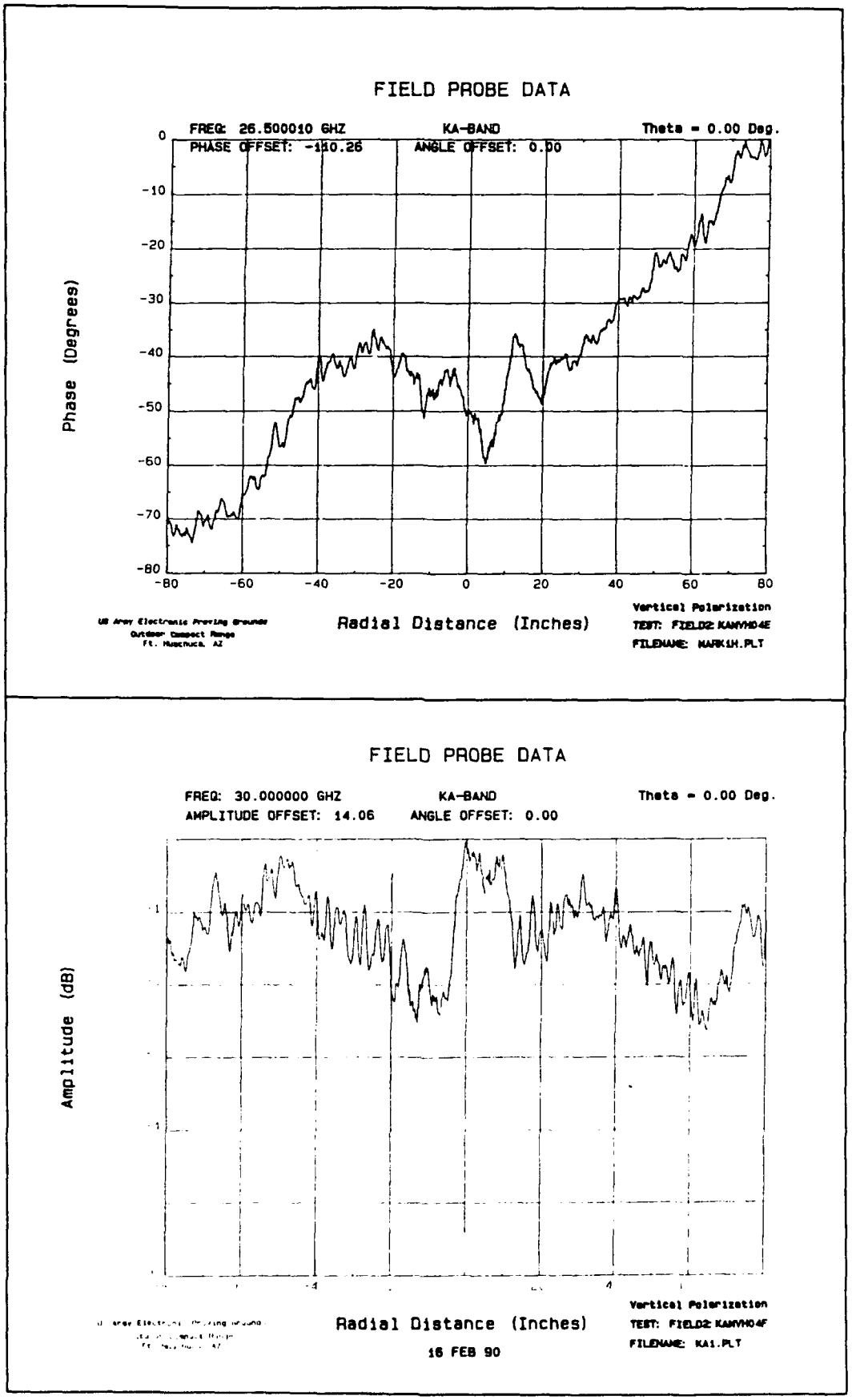

FIELD PROBE DATA
FREQ: 26.499900 GHZ
K-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 10.35
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 K4HV04C
FILENAME: K8.PLT
16 FEB 90

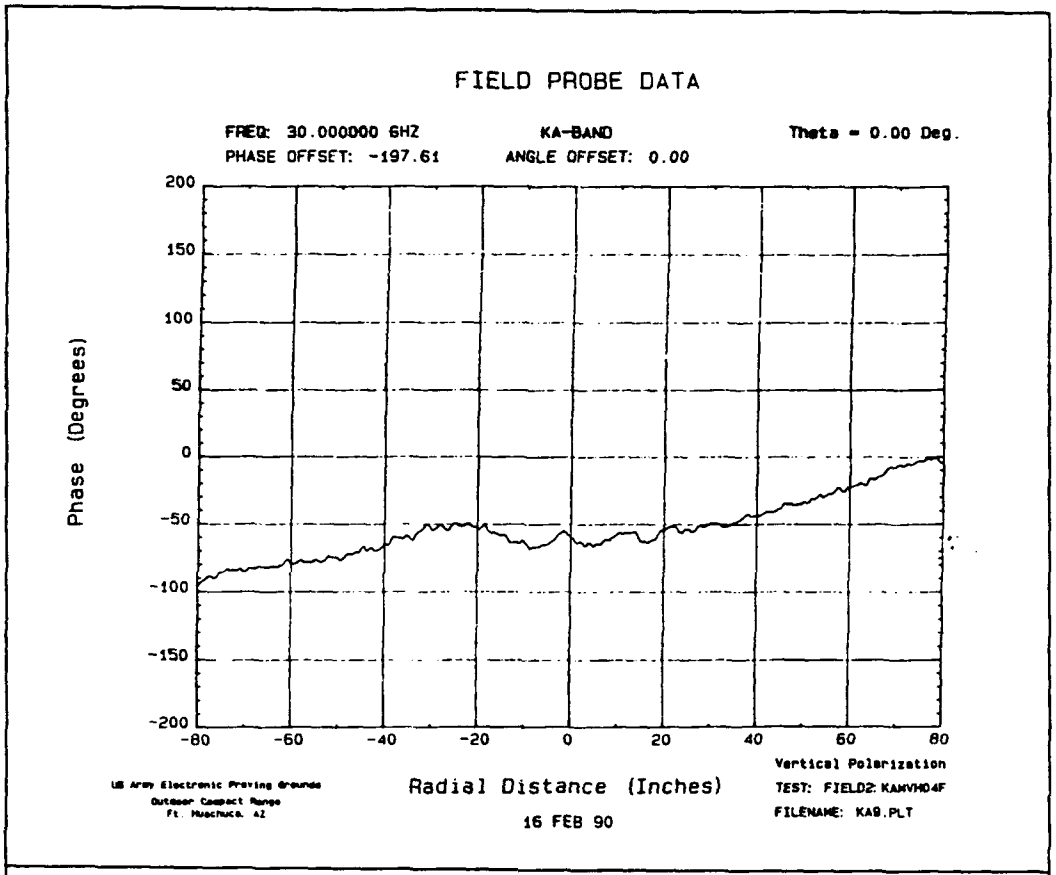

FIELD PROBE DATA
FREQ: 26.499900 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -85.95
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 K4HV04C
FILENAME: K8F.PLT
16 FEB 90...COMPENSATED

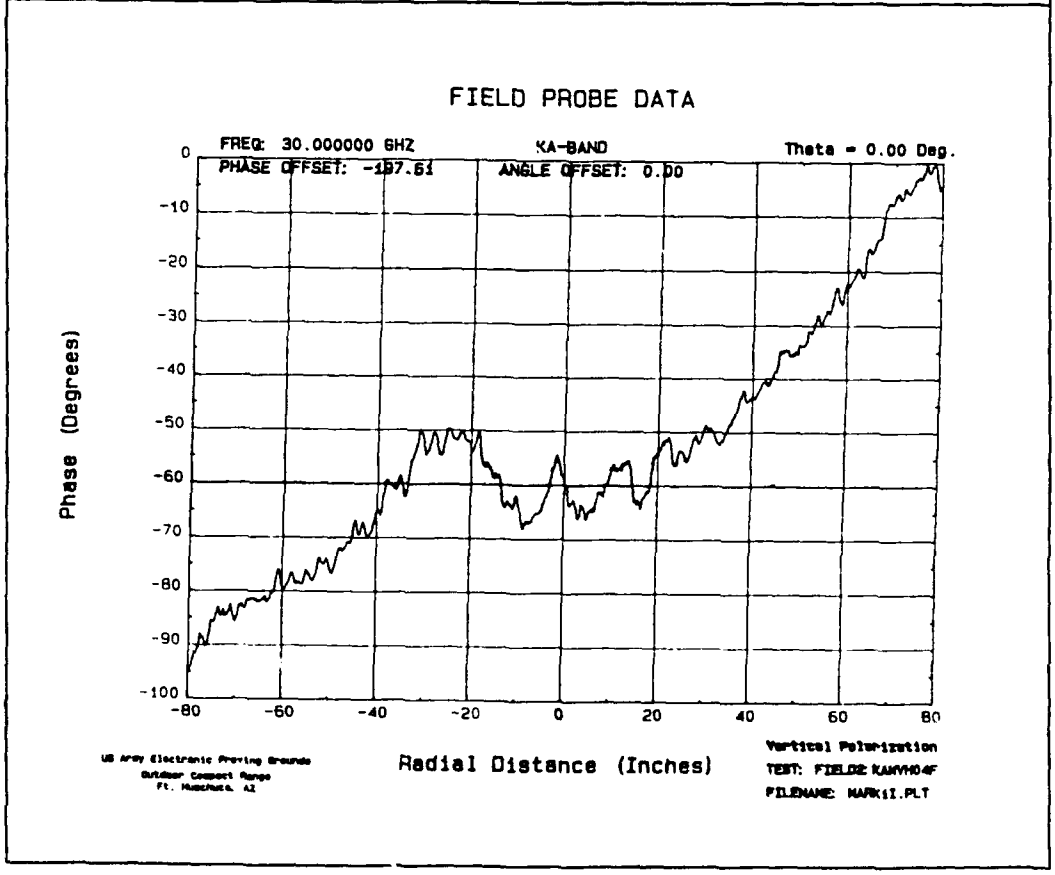

FIELD PROBE DATA
FREQ: 26.499900 GHZ
K-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -85.95
ANGLE OFFSET: 0.00
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
Phase (Degrees)
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2:106MY04C
FILENAME: MARK2N.PLT


FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 14.31
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAMVH04E
FILENAME: KA1.PLT


FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -110.26
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAMVH04E
FILENAME: KA9.PLT

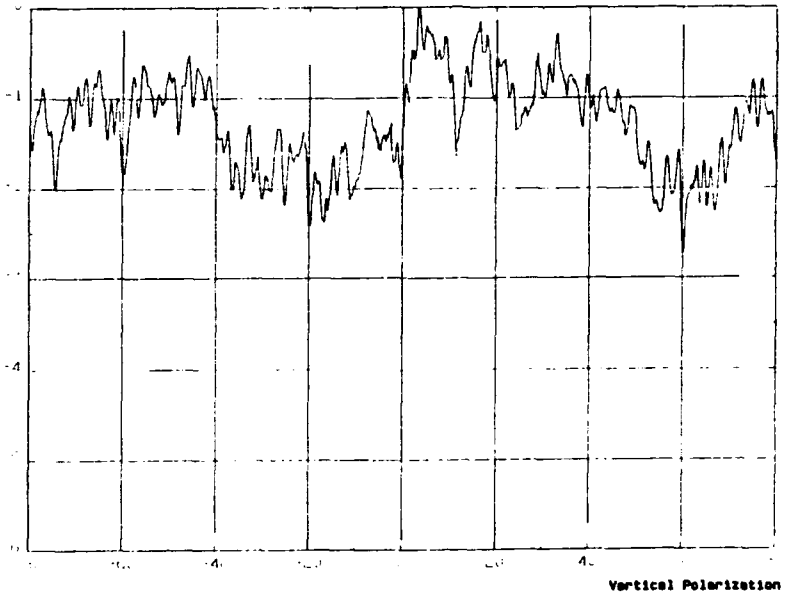

FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -110.26
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAHVH04E
FILENAME: MARK1H.PLT
FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 14.06
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAHVH04F
FILENAME: KA1.PLT


FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -197.61
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
16 FEB 90
Vertical Polarization
TEST: FIELD2: KAHVH04F
FILENAME: KA8.PLT


FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -197.61
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2: KAHVH04F
FILENAME: MARKII.PLT

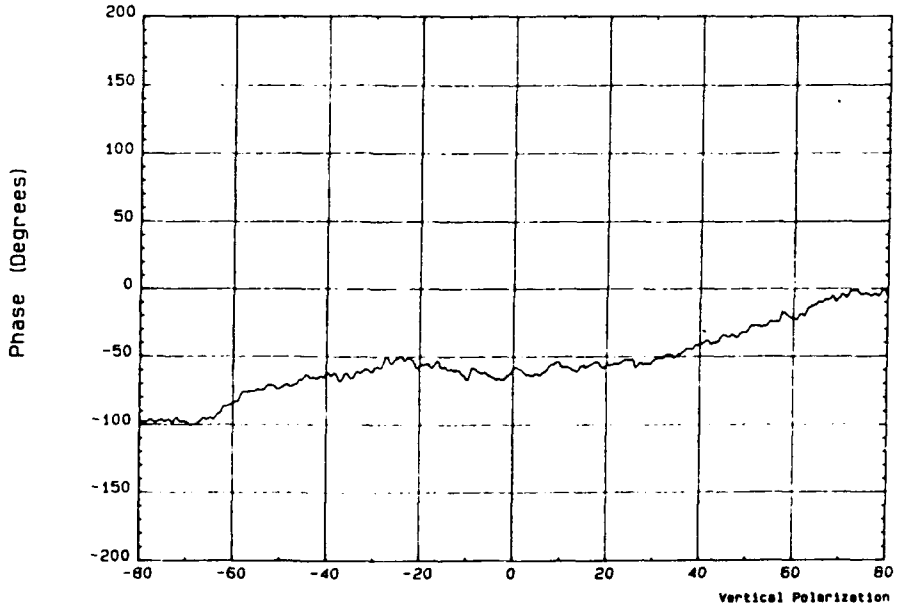
FIELD PROBE DATA

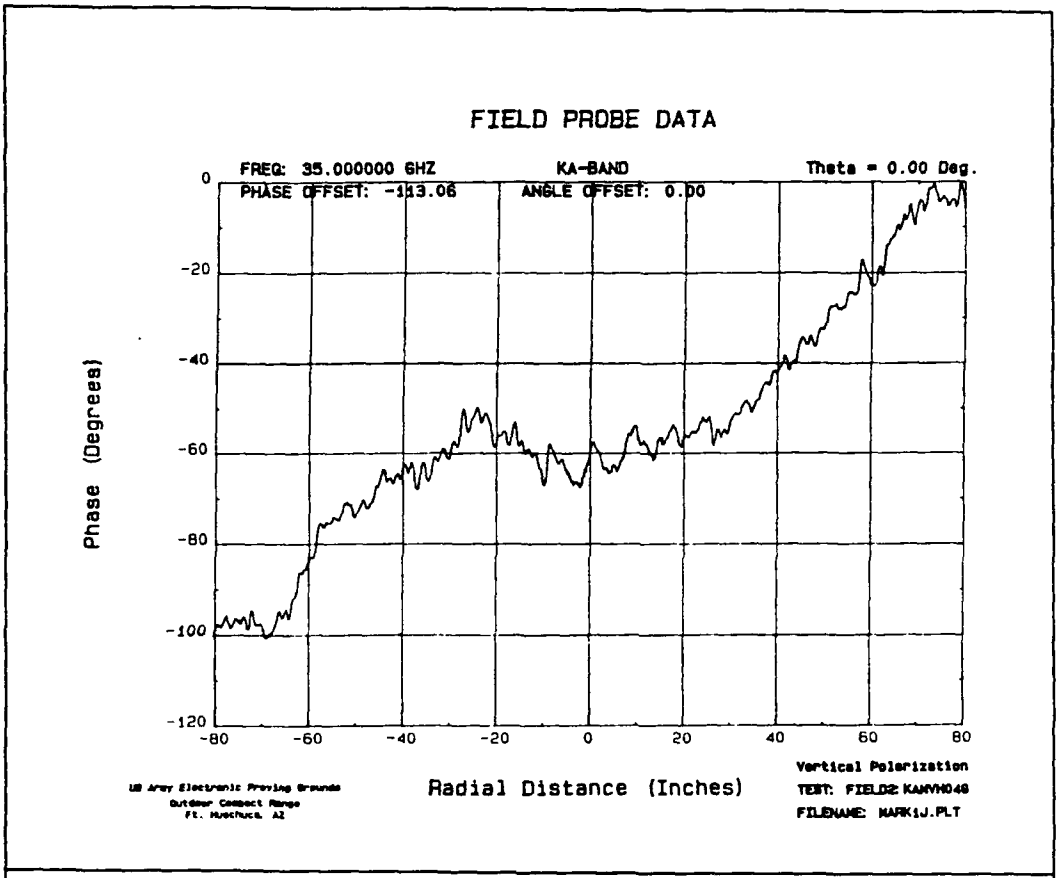
FREQ: 35.000000 GHZ KA-BAND Theta = 0.00 Deg.
AMPLITUDE OFFSET: 15.17 ANGLE OFFSET: 0.00

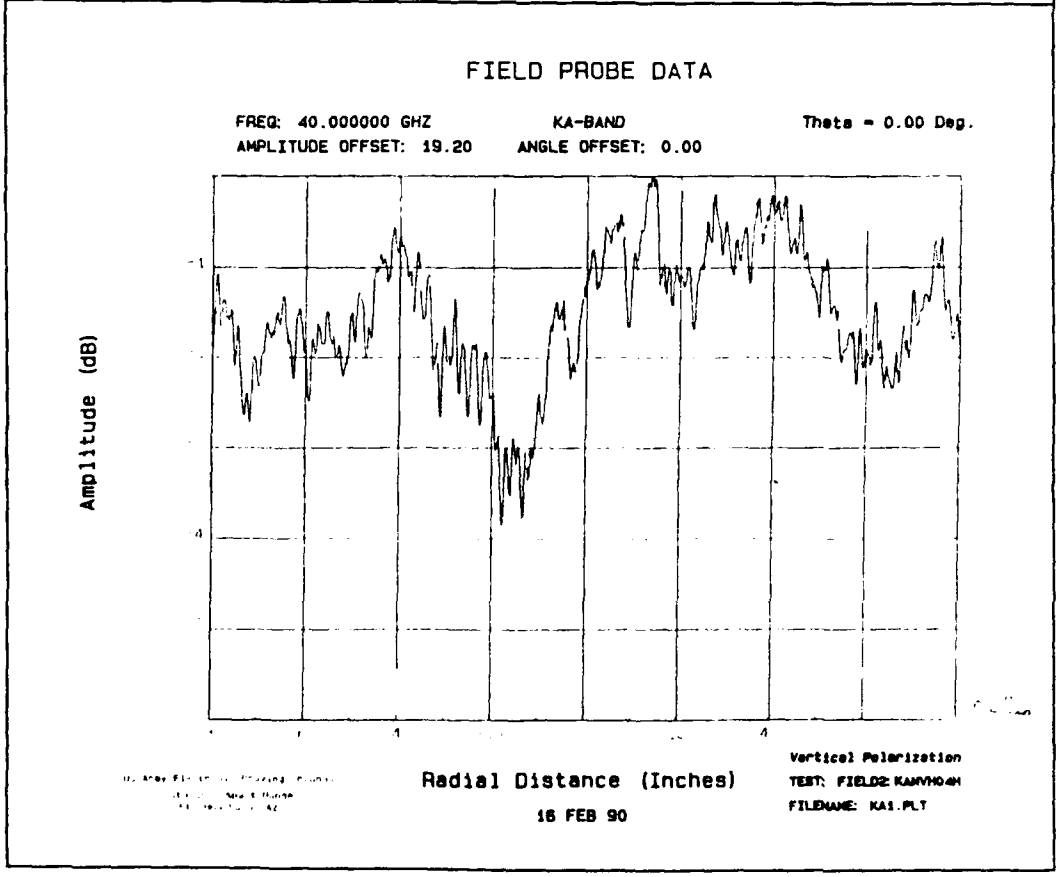


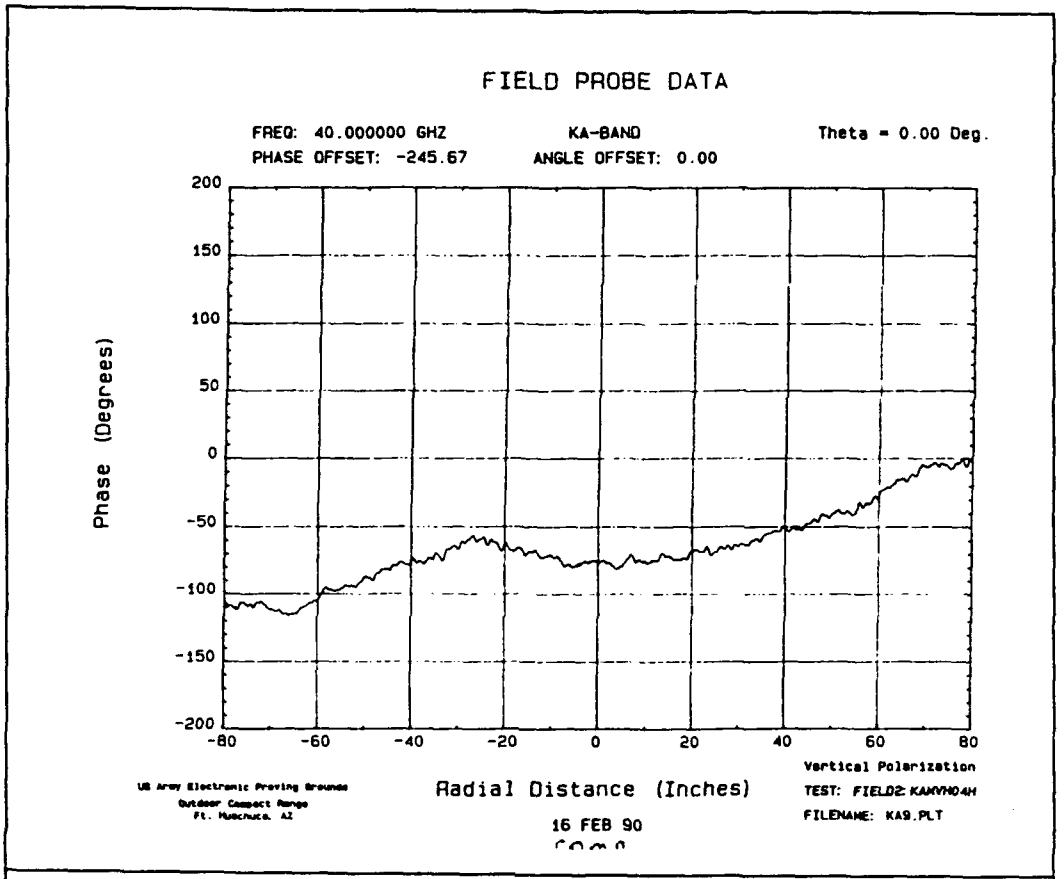
FIELD F 3E DATA

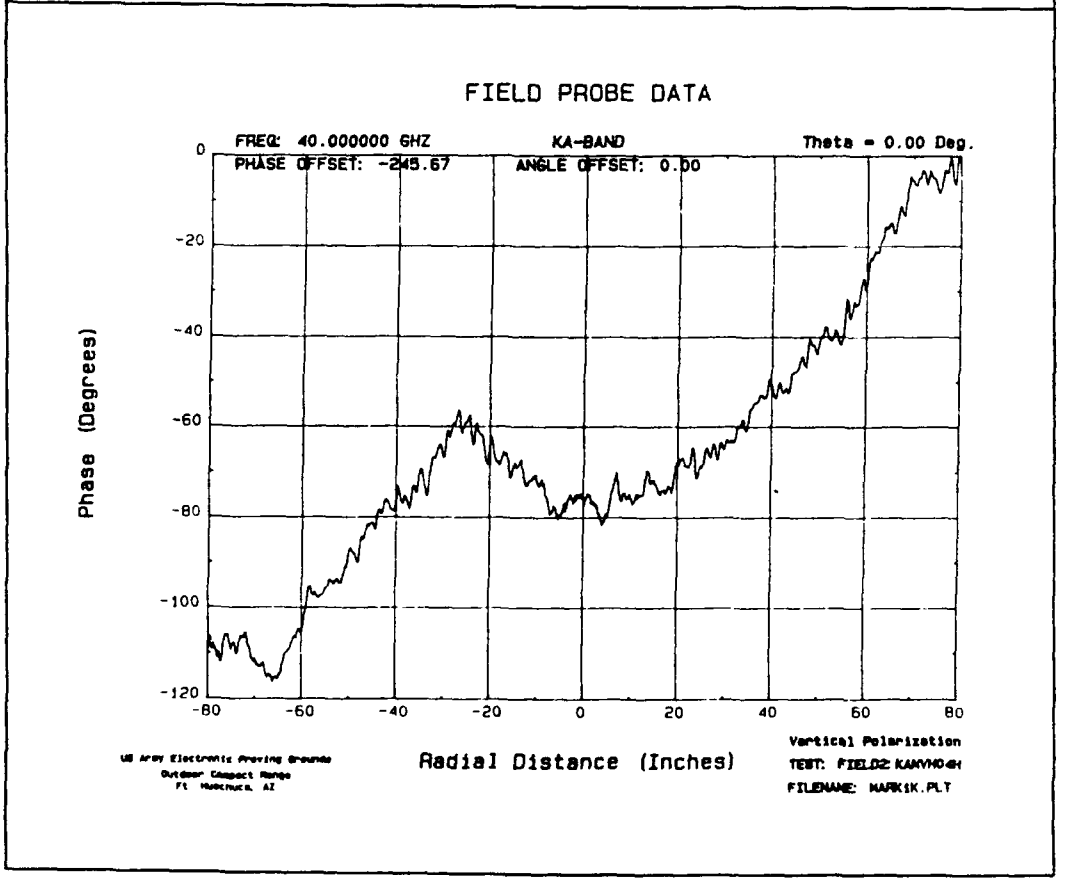
FREQ: 35.000000 GHZ KA-BAND Theta = 0.00 Deg.
PHASE OFFSET: -113.06 ANGLE OFFSET: 0.00

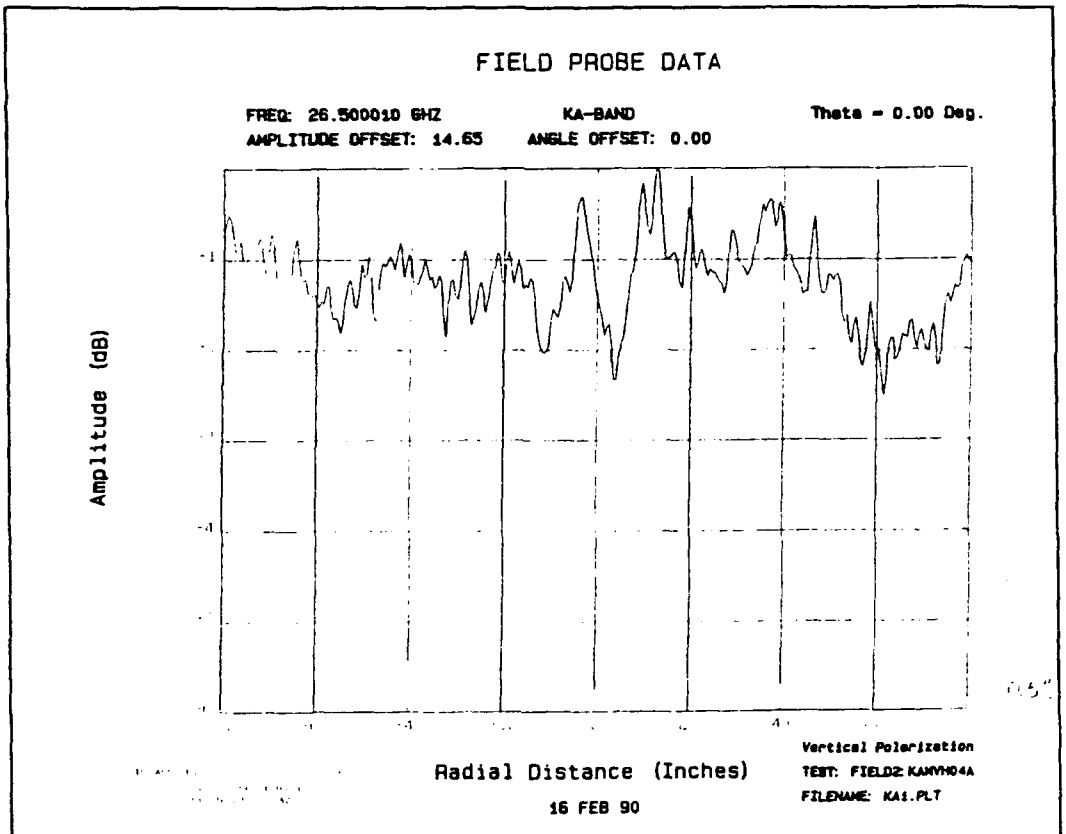


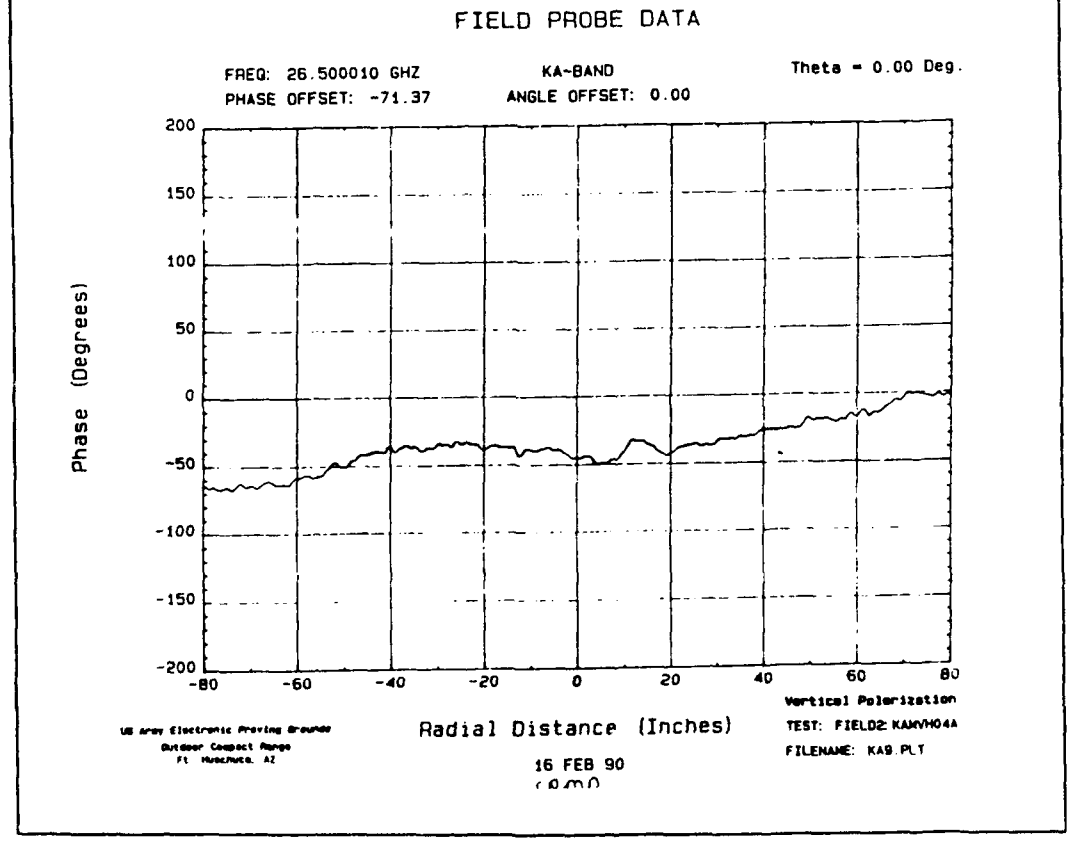

FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -113.06
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAHVH048
FILENAME: HARK1J.PLT

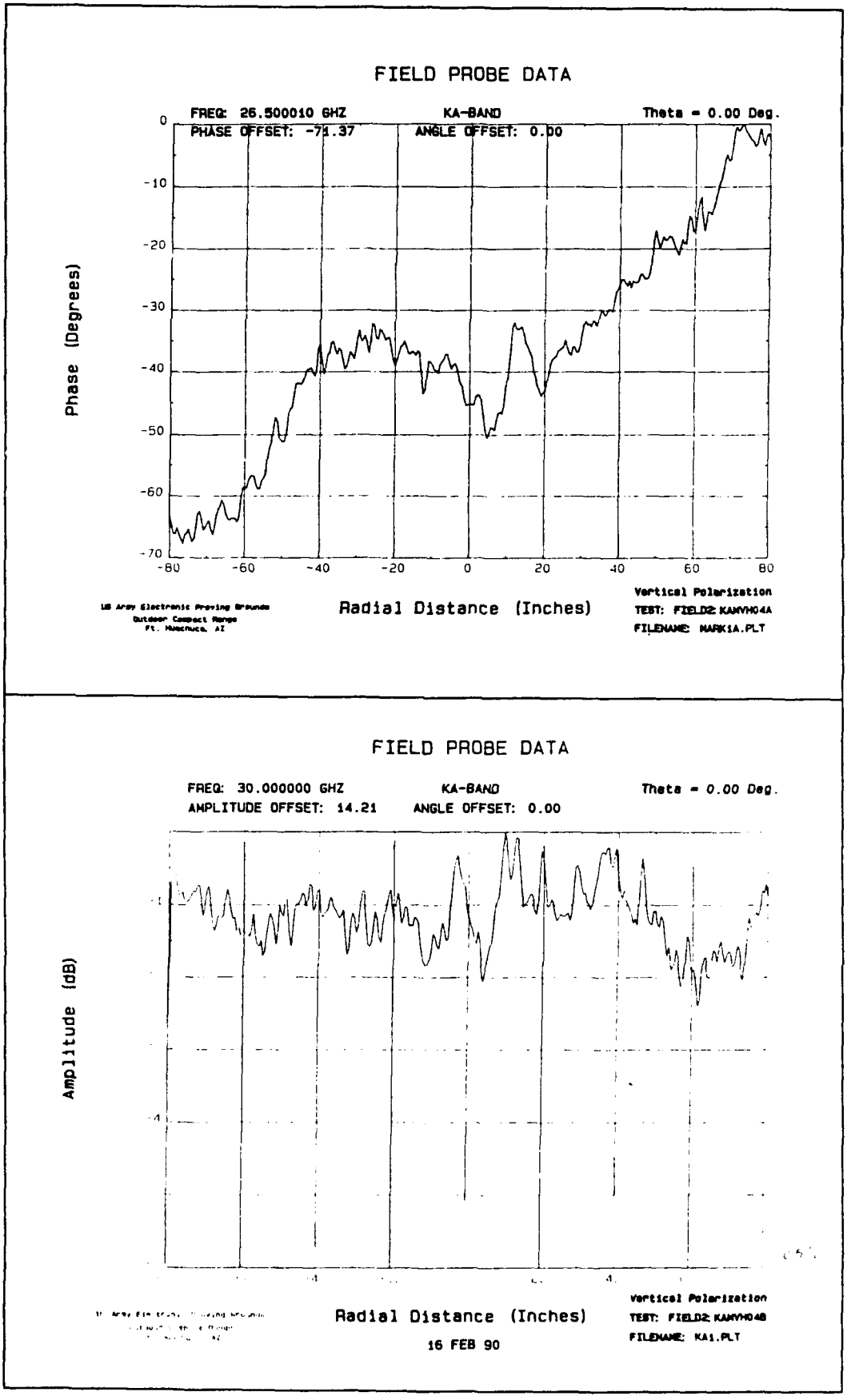

FIELD PROBE DATA
FREQ: 40.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 19.20
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAHVH04H
FILENAME: KA1.PLT

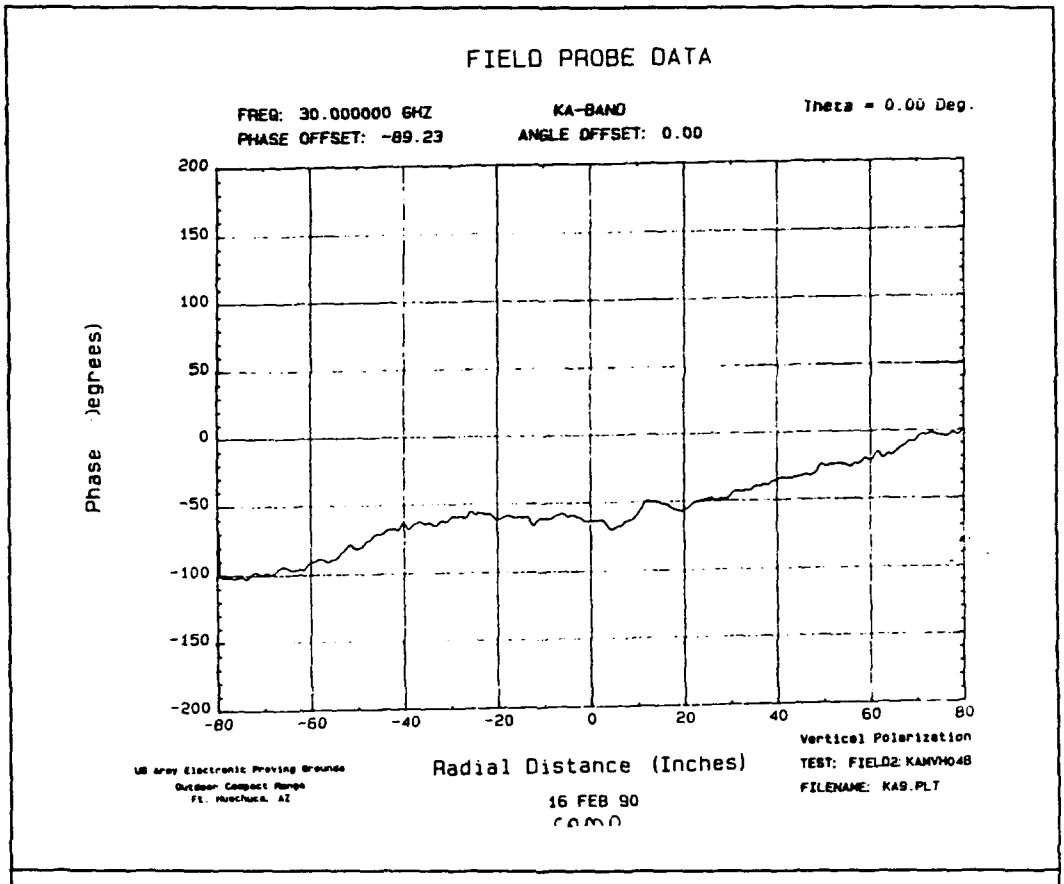

FIELD PROBE DATA
FREQ: 40.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -245.67
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2:KAHVH04H
FILENAME: KA9.PLT
16 FEB 90

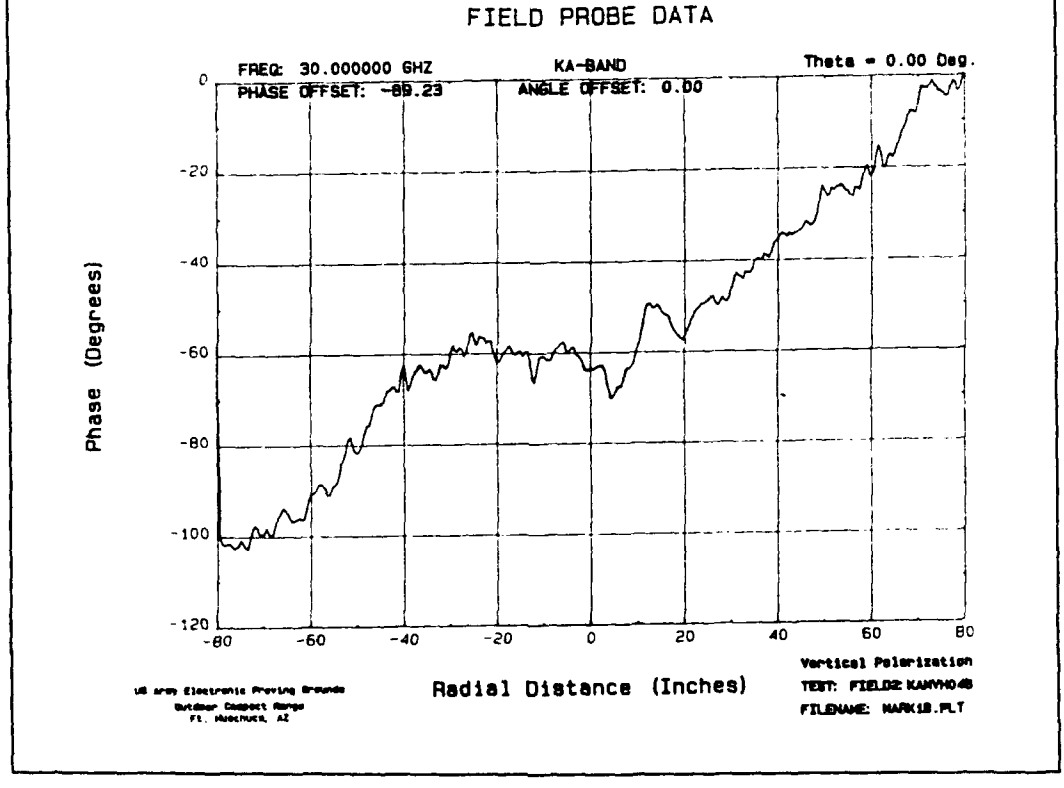

FIELD PROBE DATA
FREQ: 40.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -245.67
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2:KAHVH04H
FILENAME: MARK1K.PLT

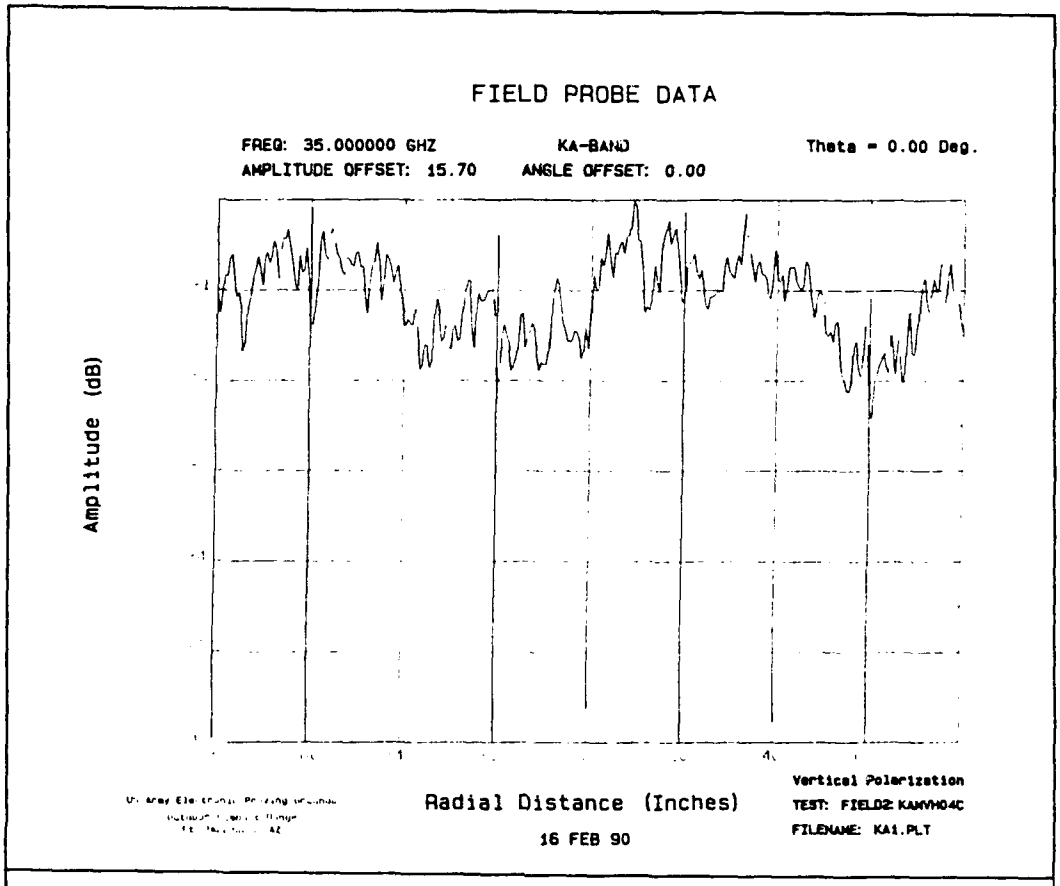

FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 14.65
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAMVH04A
FILENAME: KA1.PLT

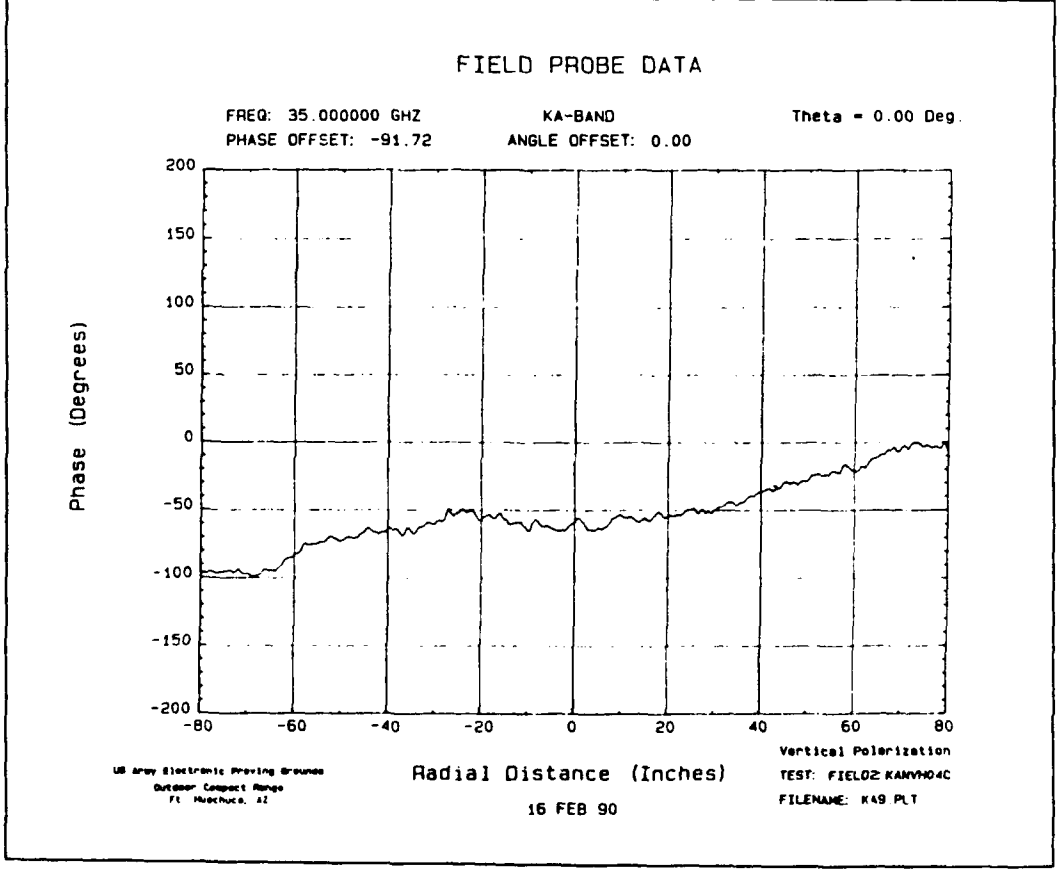

FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -71.37
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAMVH04A
FILENAME: KA9.PLT
US Army Electronic Proving Ground
Outdoor Compact Range
Ft Huachuca, AZ

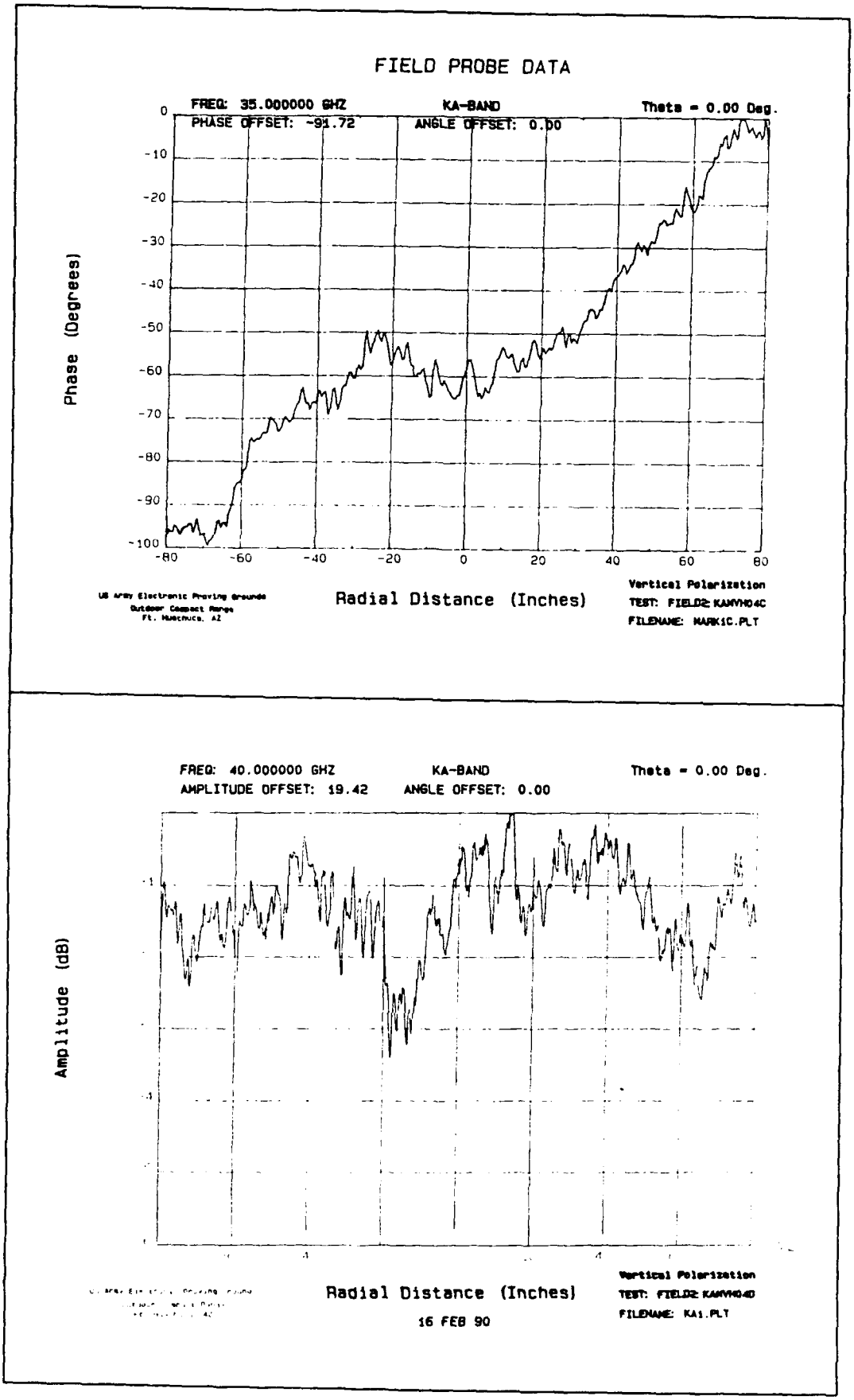

FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -71.37
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAHVH04A
FILENAME: MARK1A.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 14.21
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAHVH04B
FILENAME: KA1.PLT

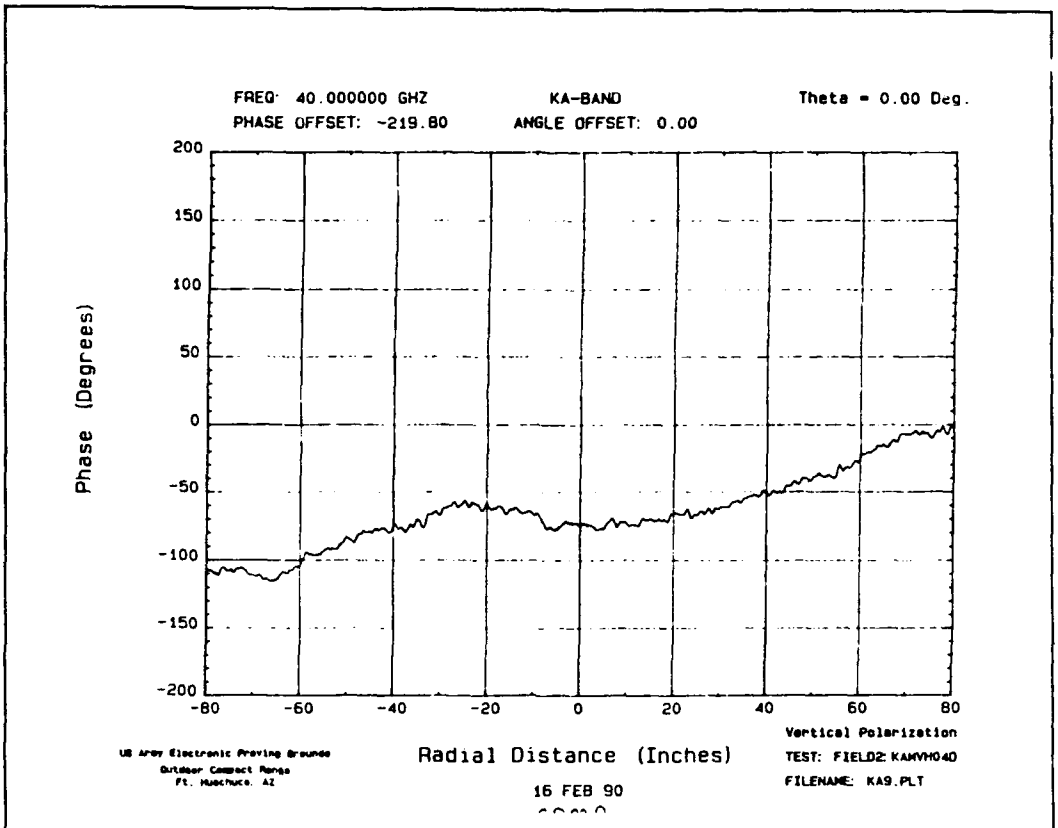

FIELD PROBE DATA
FREQ: 30.000000 GHZ
PHASE OFFSET: -89.23
KA-BAND
ANGLE OFFSET: 0.00
Theta = 0.00 Deg.
Phase Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAMVH04B
FILENAME: KA9.PLT
16 FEB 90

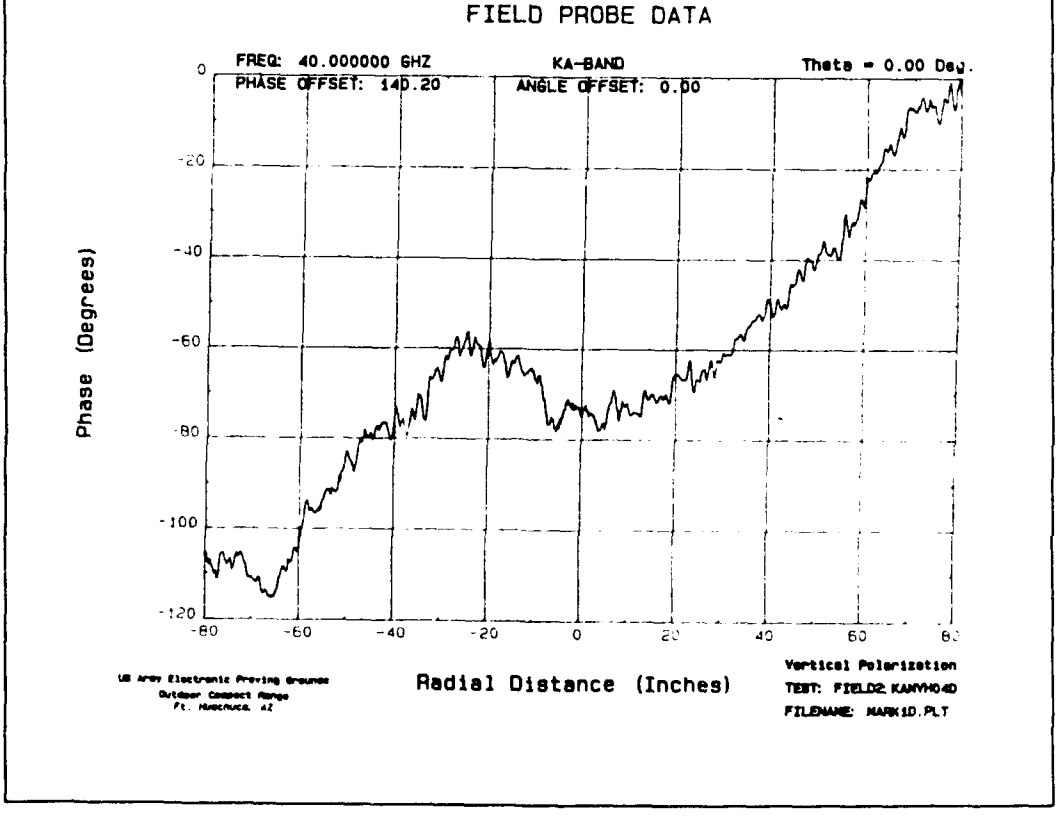

FIELD PROBE DATA
FREQ: 30.000000 GHZ
PHASE OFFSET: -89.23
KA-BAND
ANGLE OFFSET: 0.00
Theta = 0.00 Deg.
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAMVH04B
FILENAME: MARK18.PLT

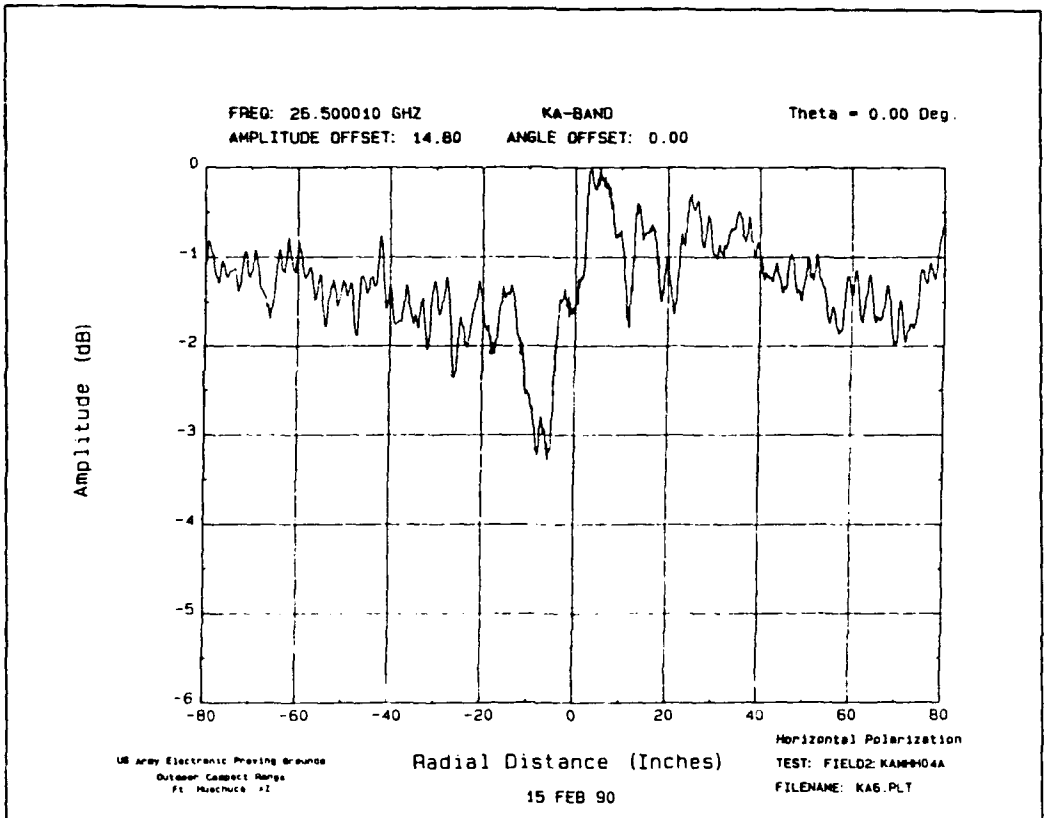

FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 15.70
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAMVH04C
FILENAME: KA1.PLT


FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -91.72
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAMVH04C
FILENAME: KA9 PLT

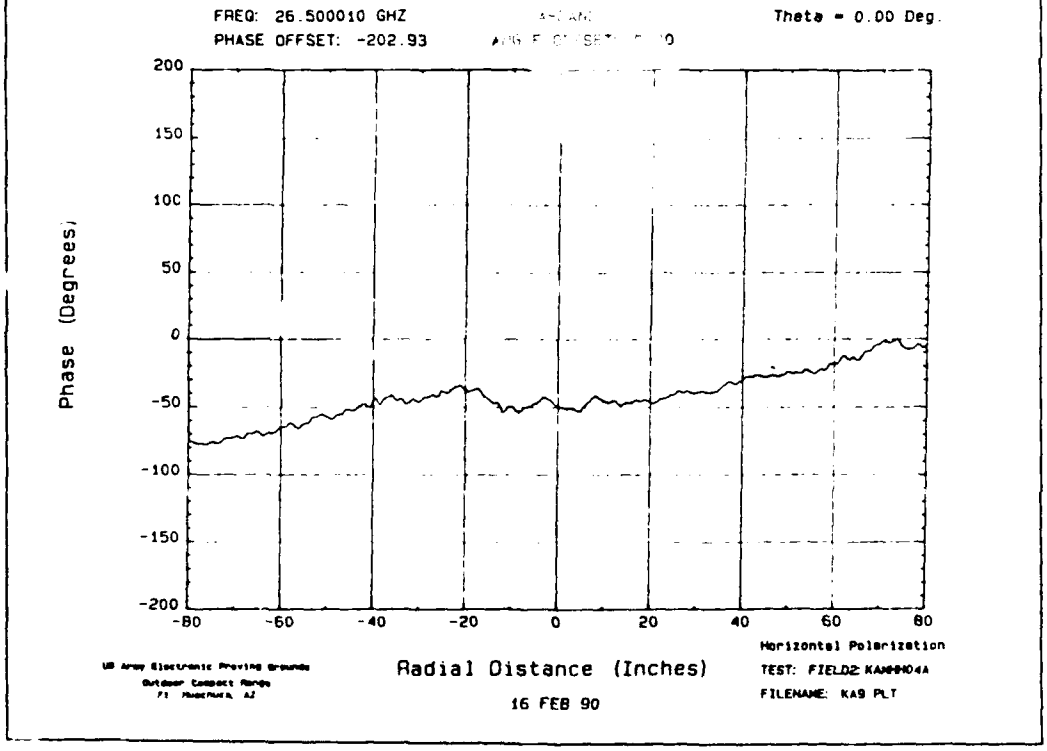

FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -91.72
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Vertical Polarization
TEST: FIELD2 KAMVH04C
FILENAME: MARK1C.PLT
FREQ: 40.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 19.42
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAMVH04D
FILENAME: KA1.PLT

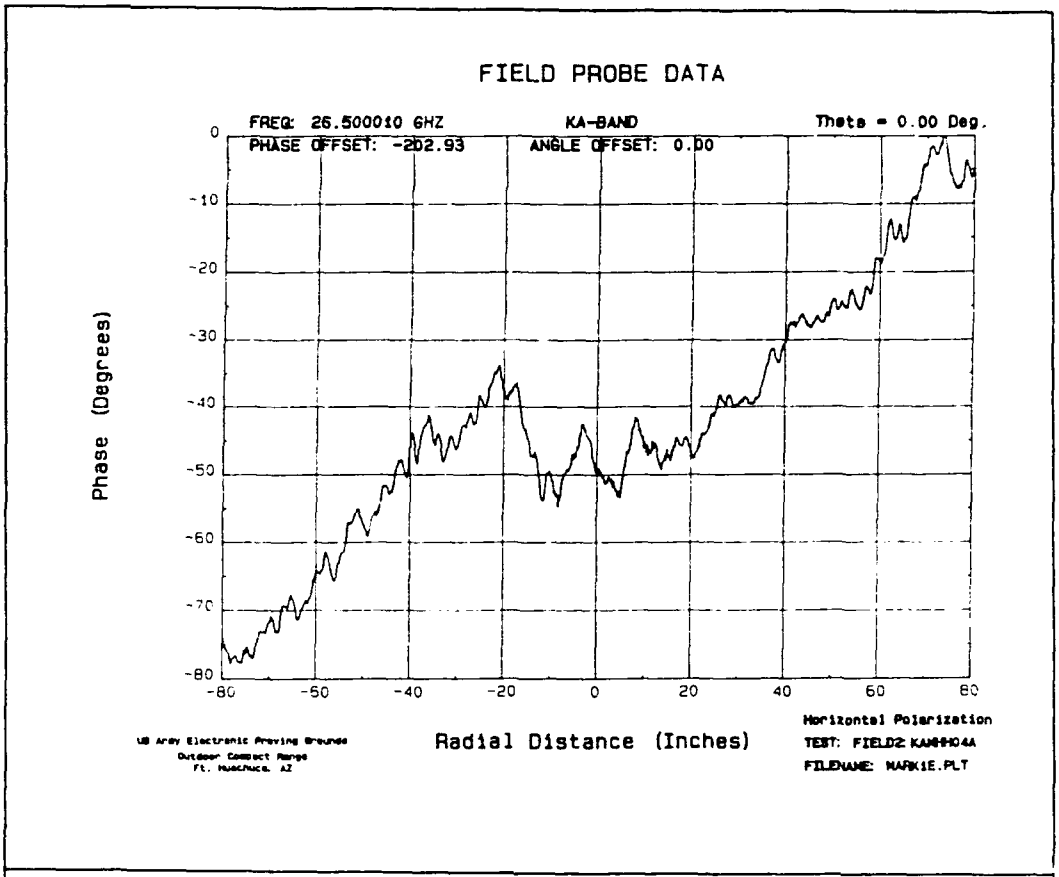

FREQ: 40.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -219.80
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAMVH040
FILENAME: KA9.PLT
16 FEB 90

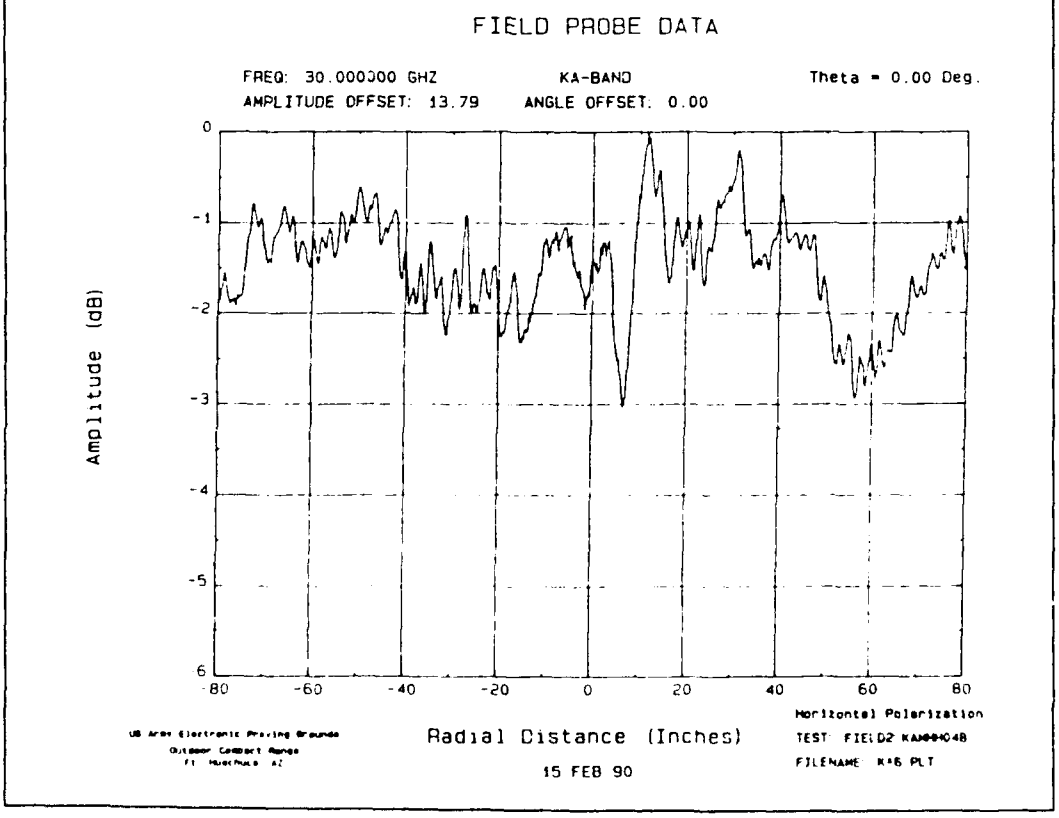

FIELD PROBE DATA
FREQ: 40.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 140.20
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-80
-60
-40
-20
0
20
40
60
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAMVH040
FILENAME: MARK1D.PLT

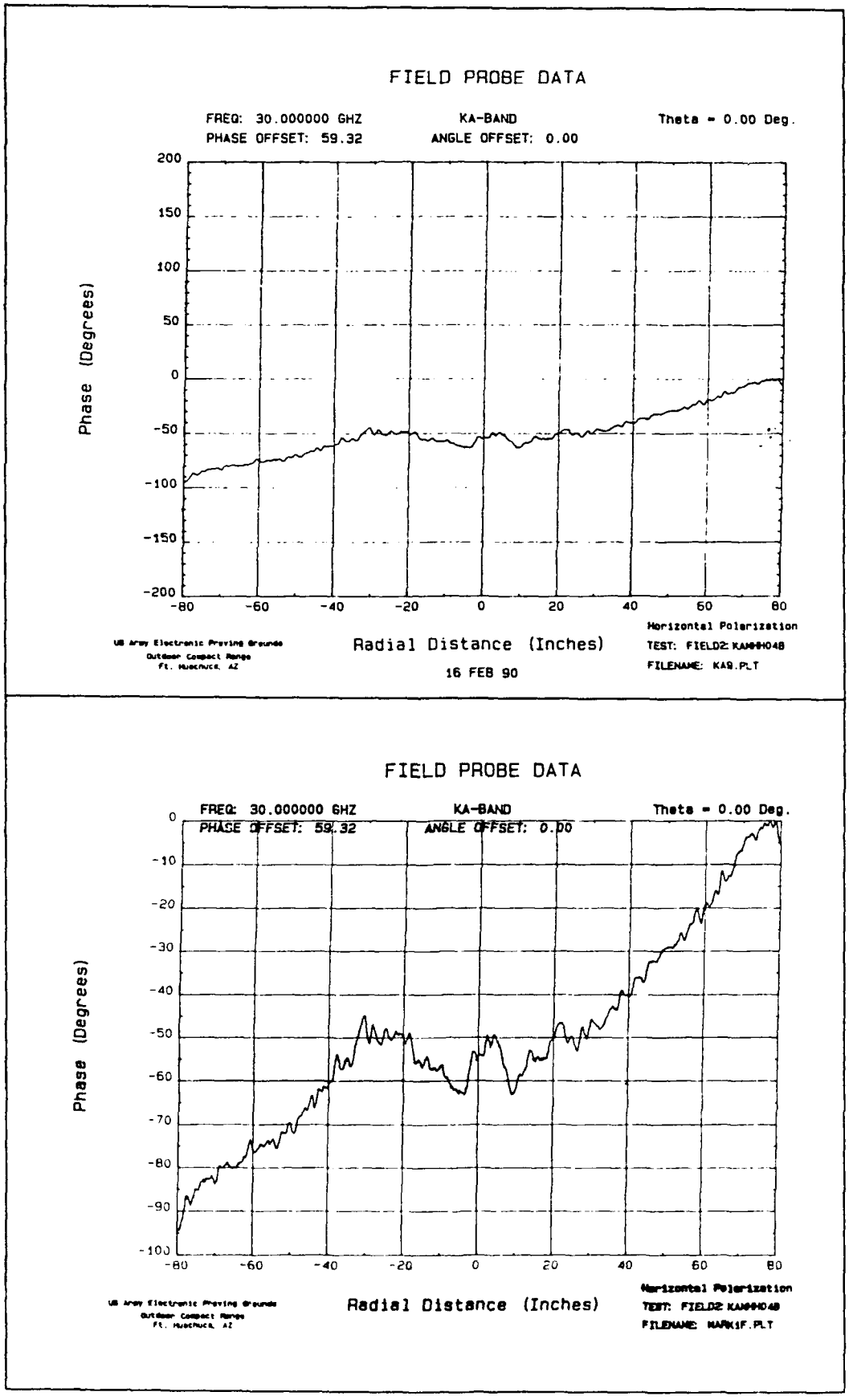


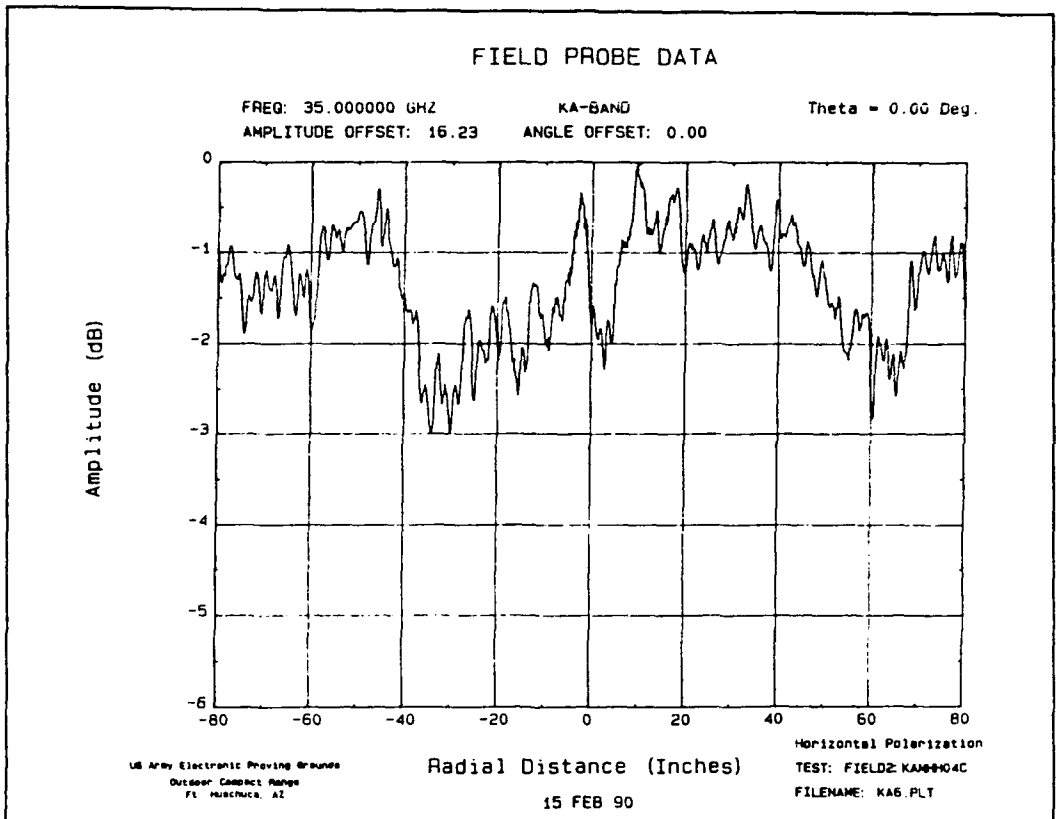
FIELD PROBE DATA

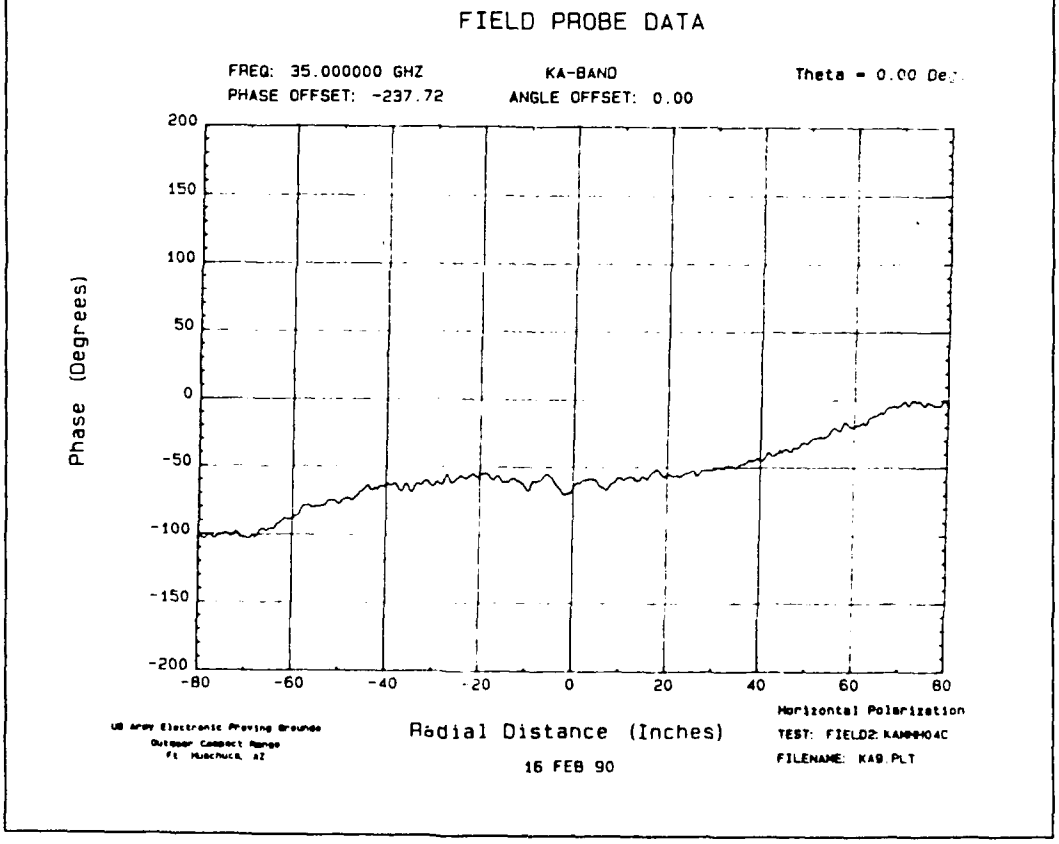


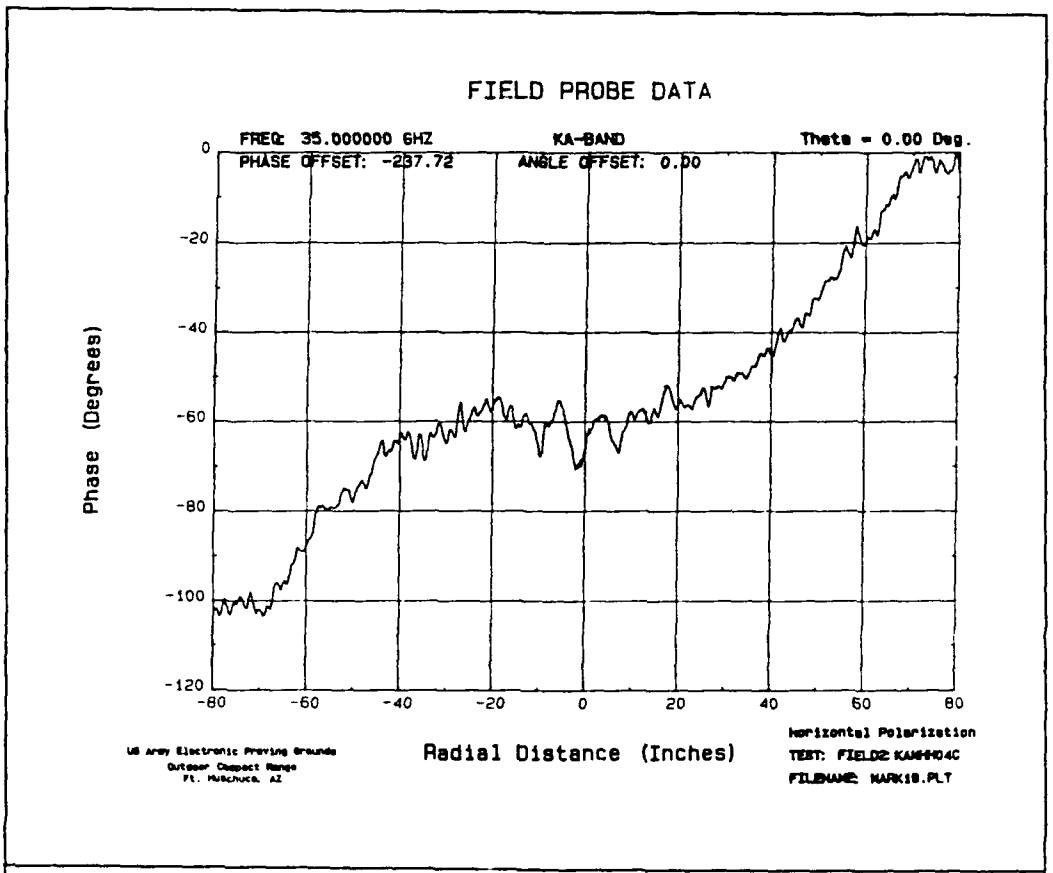

FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -202.93
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KAHH04A
FILENAME: MARK1E.PLT

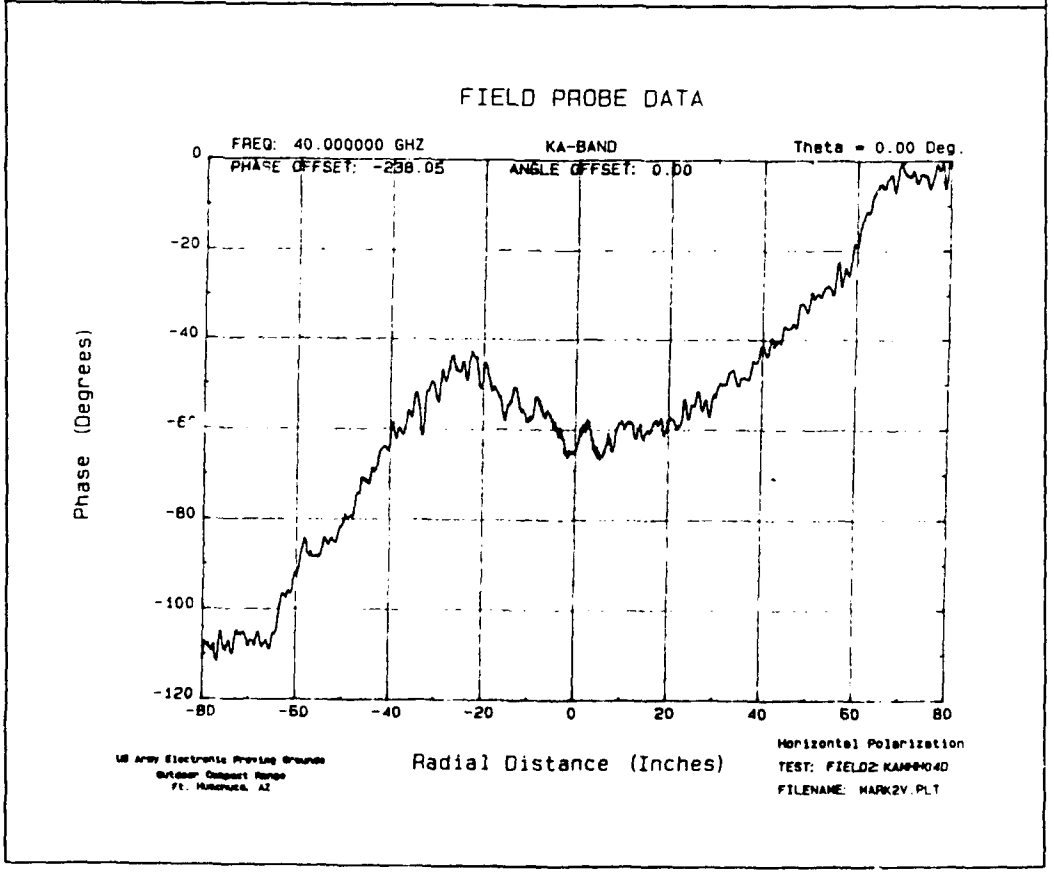

FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 13.79
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KAHH04B
15 FEB 90


FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 59.32
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2: KA88H048
FILENAME: KA8.PLT
FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: 59.32
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2: KA88H048
FILENAME: MARK1F.PLT


FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
AMPLITUDE OFFSET: 16.23
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-1
-2
-3
-4
-5
-6
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft Huachuca, AZ
15 FEB 90
Horizontal Polarization
TEST: FIELD2: KA0604C
FILENAME: KA6.PLT

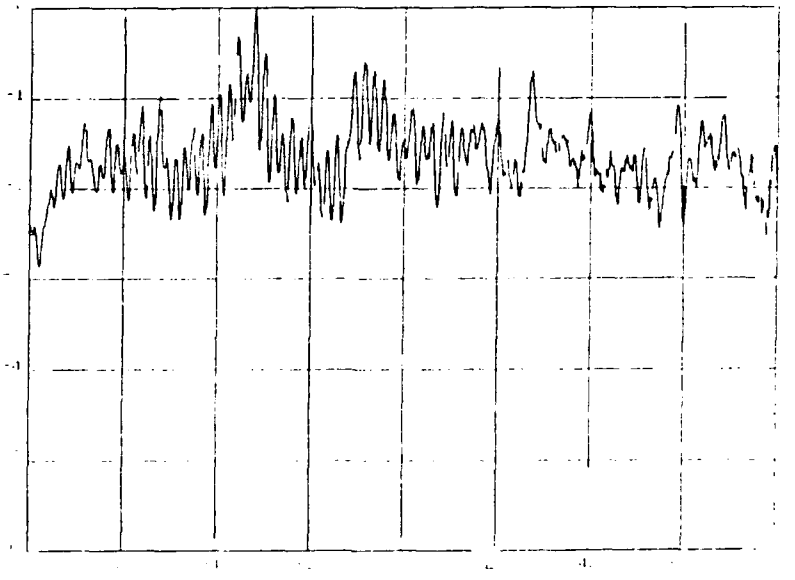

FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -237.72
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft Huachuca, AZ
16 FEB 90
Horizontal Polarization
TEST: FIELD2: KA0604C
FILENAME: KA9.PLT


FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -287.72
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-60
-80
-100
-120
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 KA##H04C
FILENAME: MARK1B.PLT


FIELD PROBE DATA
FREQ: 40.000000 GHZ
KA-BAND
Theta = 0.00 Deg.
PHASE OFFSET: -298.05
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-20
-40
-80
-100
-120
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
Horizontal Polarization
TEST: FIELD2 KA##H04D
FILENAME: MARK2V.PLT

FIELD PROBE DATA

FREQ: 26.500010 GHZ KA-BAND Theta = 90.00 Deg.
AMPLITUDE OFFSET: 14.12 ANGLE OFFSET: 0.00



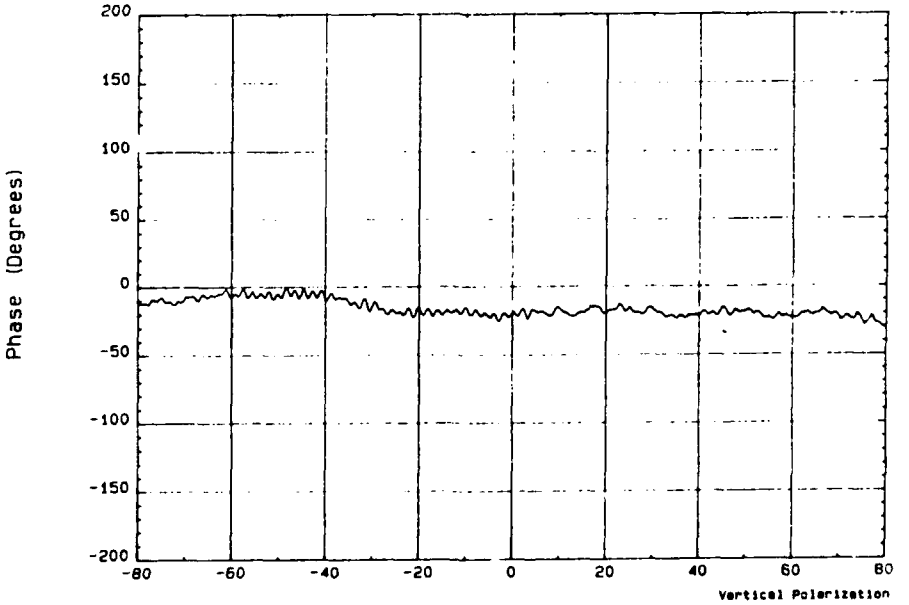
Radial Distance (Inches)

16 FEB 90

Vertical Polarizatior
TEST: FIELD2: KAMVV04A
FILENAME: KA3.PLT

FIELD PROBE DATA

FREQ: 26.500010 GHZ KA-BAND Theta = 90.00 Deg.
PHASE OFFSET: -124.87 ANGLE OFFSET: 0.00

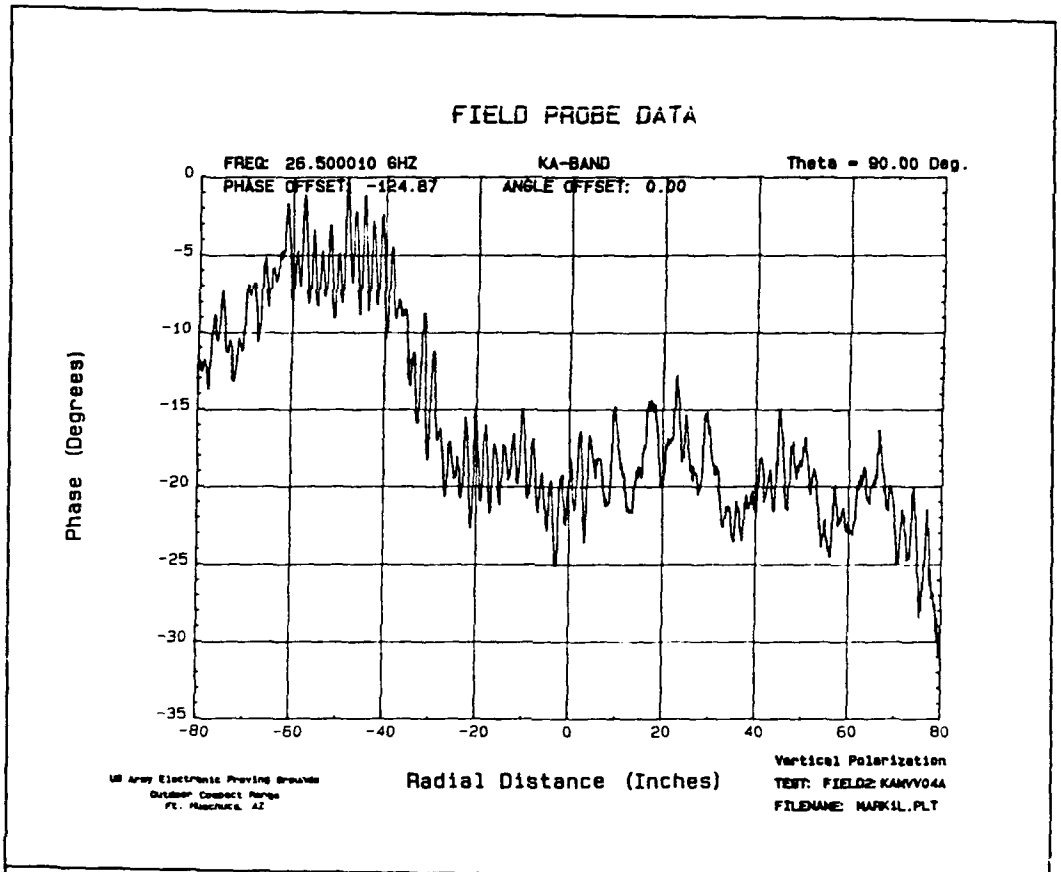


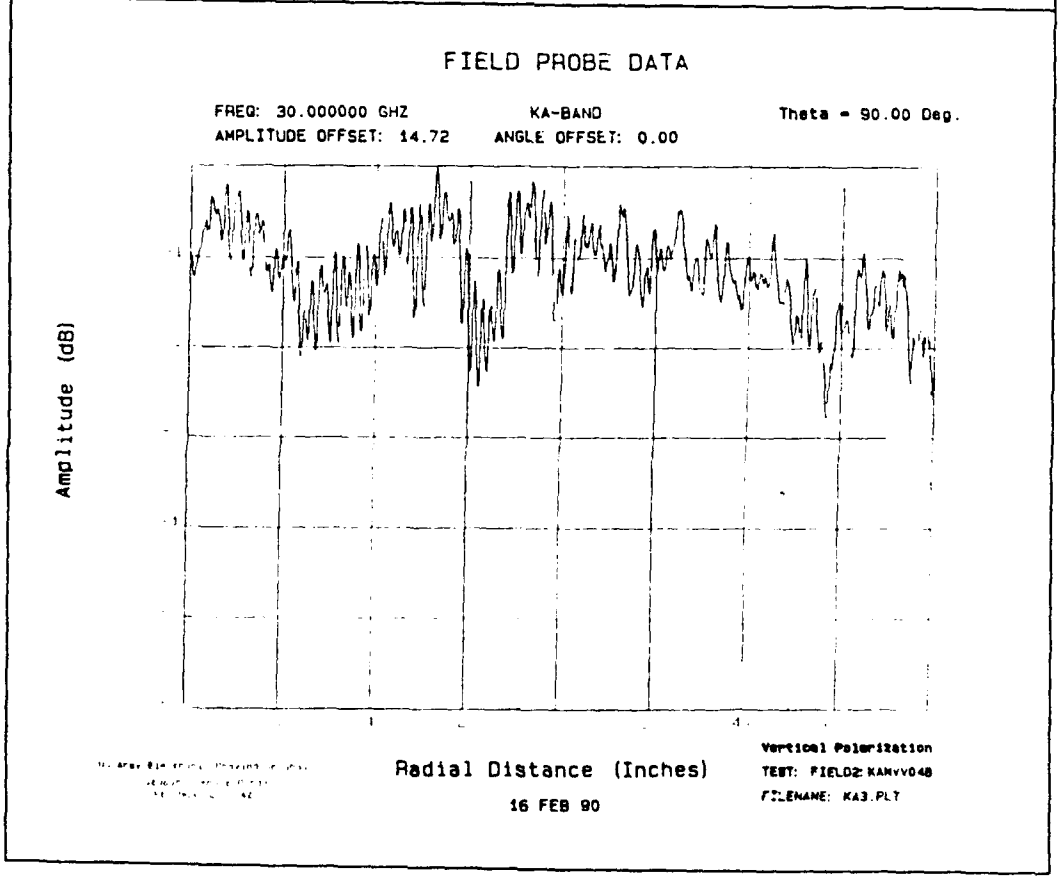
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft Huachuca, AZ

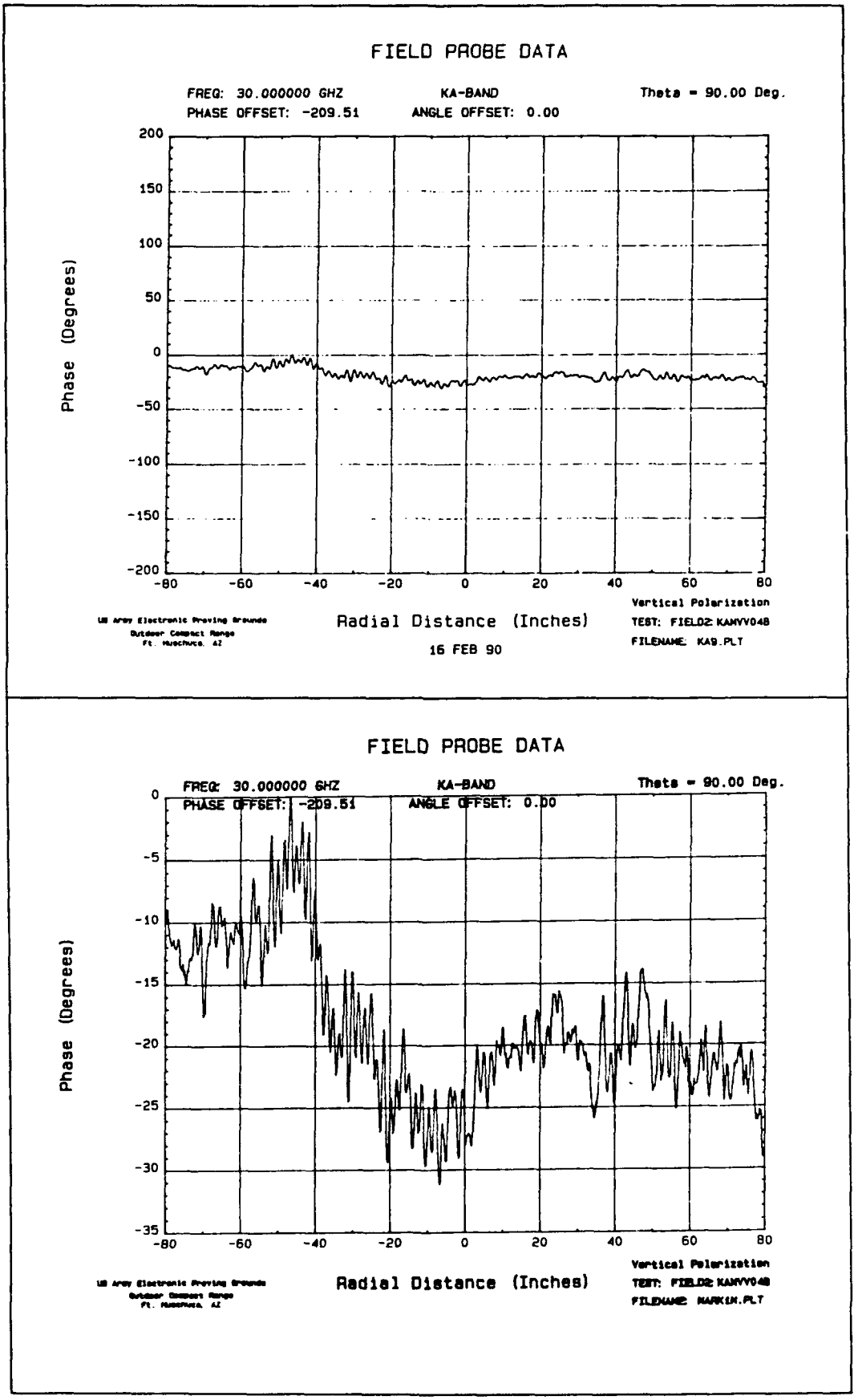
Radial Distance (Inches)

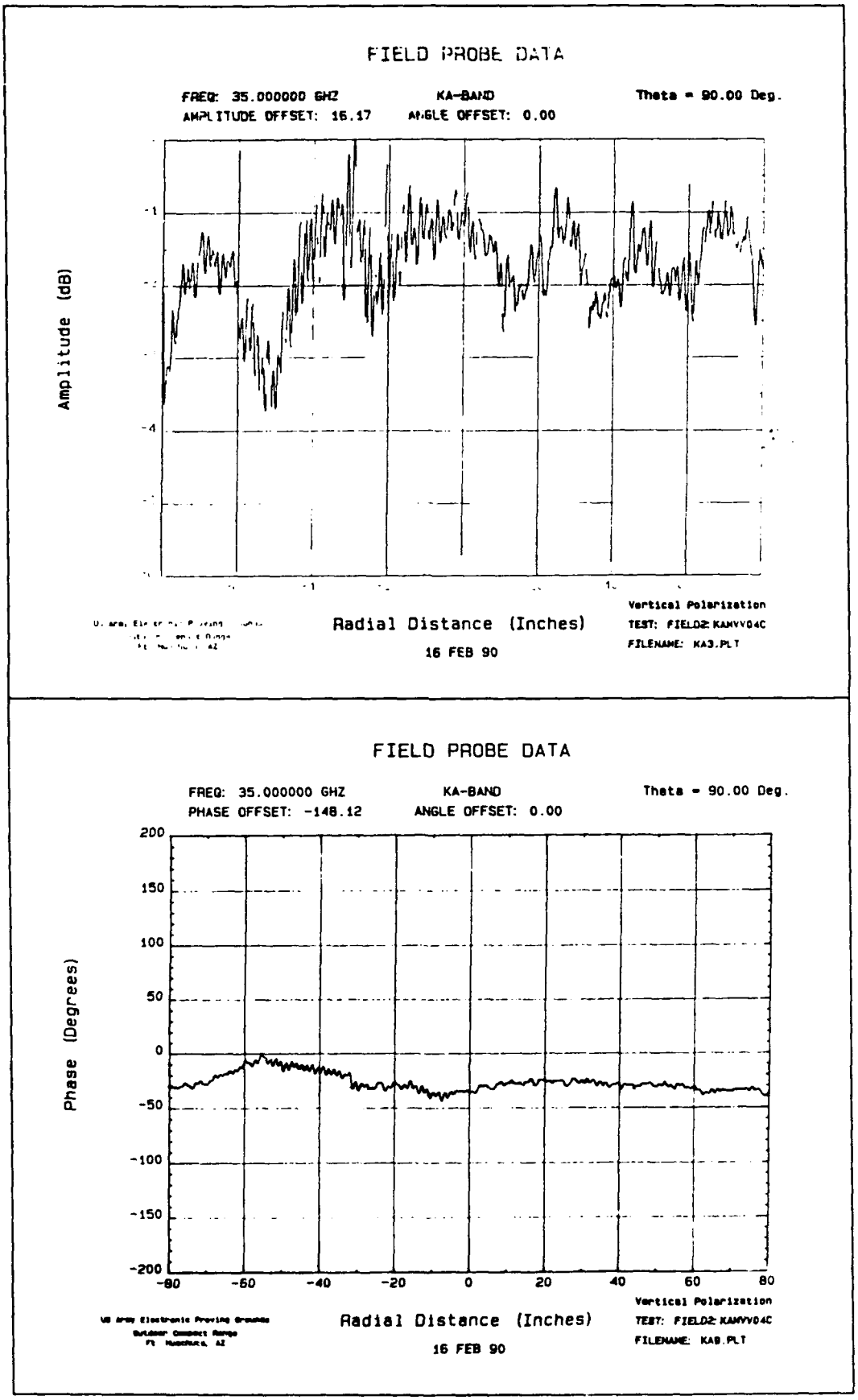
16 FEB 90
camp

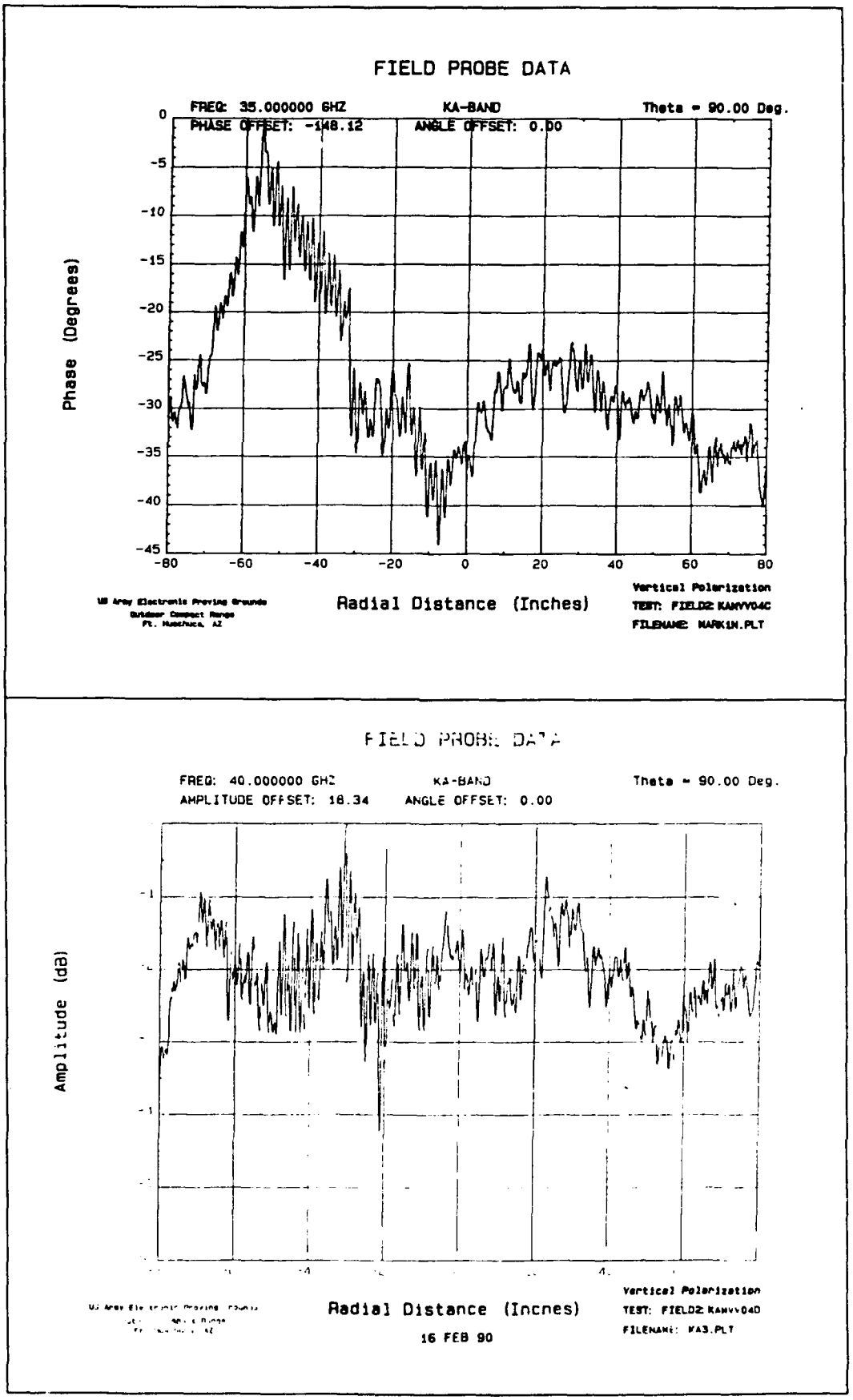
Vertical Polarization
TEST: FIELD2: KAMVV04A
FILENAME: KA9.PLT

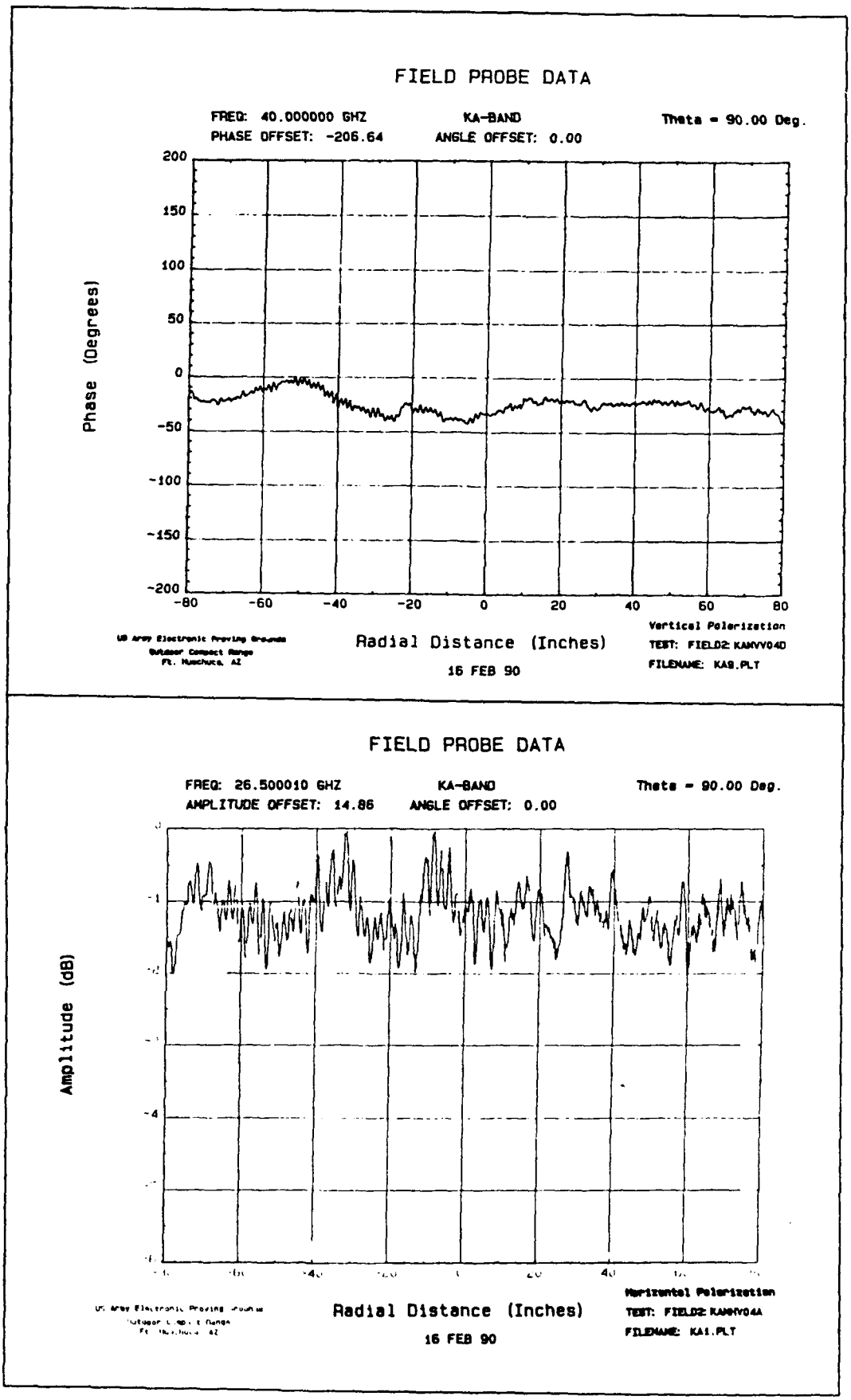

FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -124.87
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAHVV04A
FILENAME: MARK1L.PLT

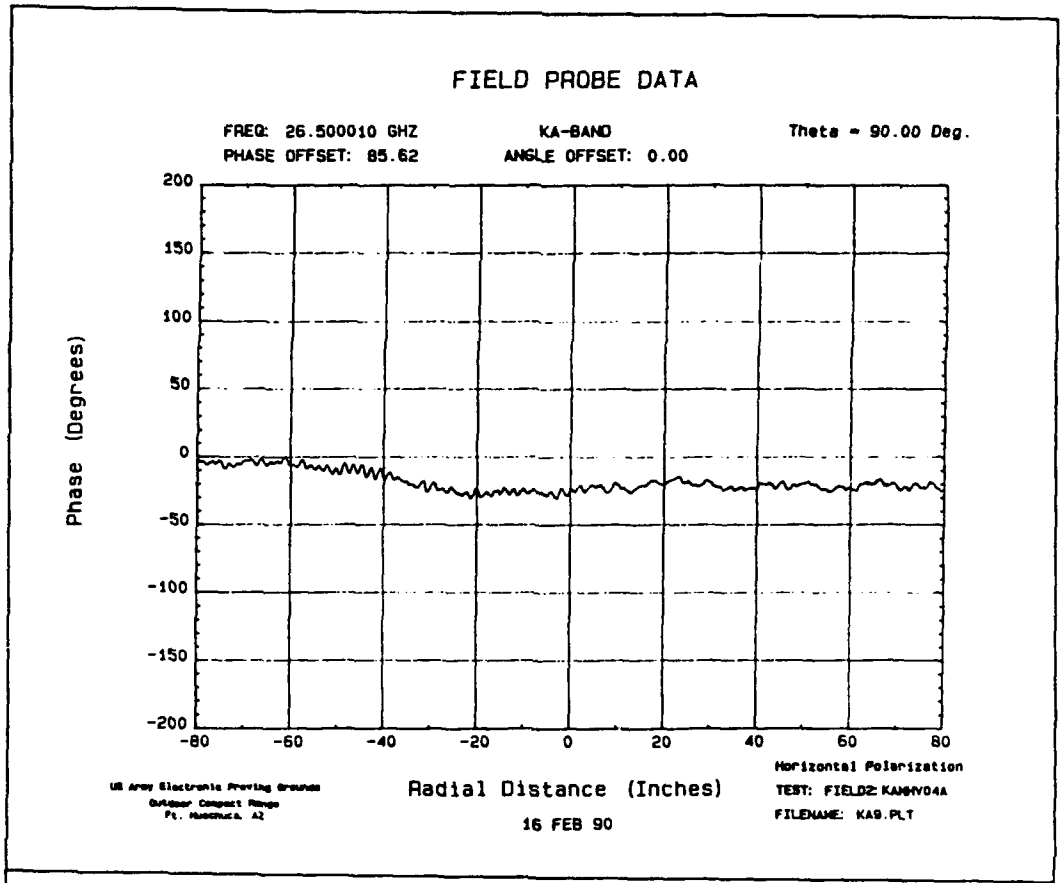

FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 14.72
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAHVV04B
FILENAME: KA3.PLT

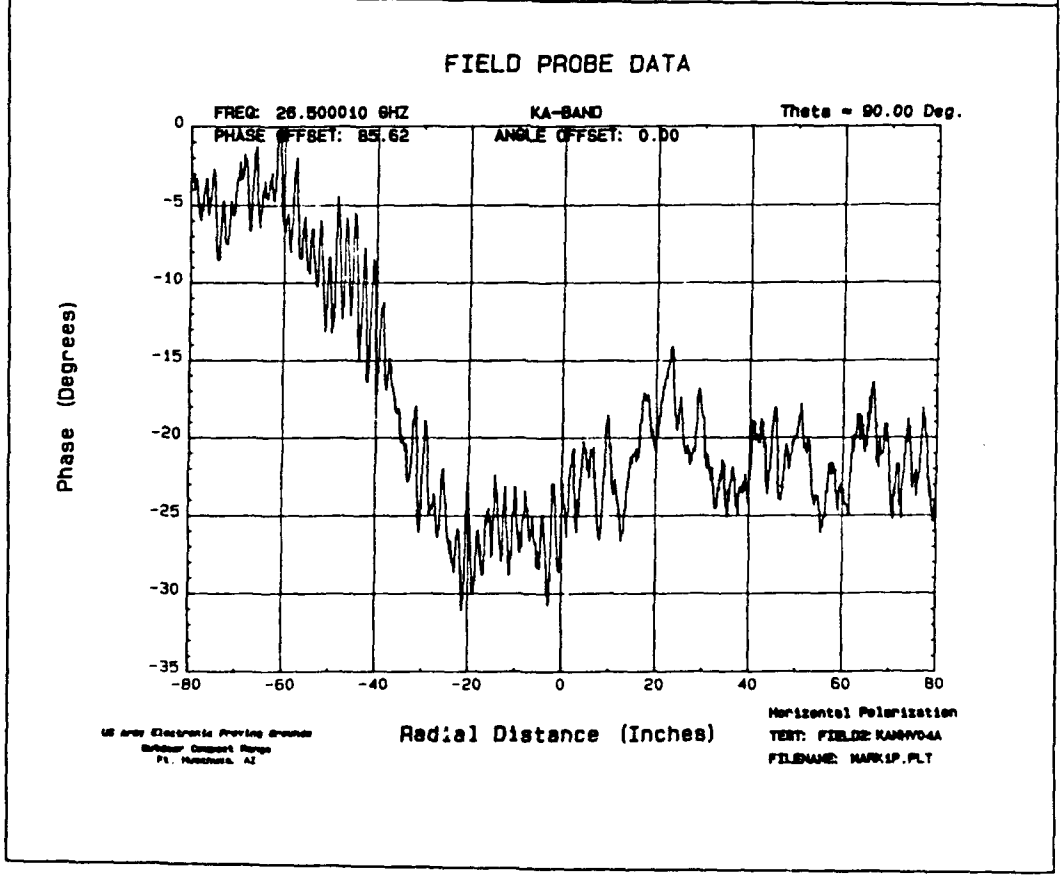

FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -209.51
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAHVV04B
FILENAME: KA9.PLT
16 FEB 90
FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -209.51
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
FILENAME: MARKIM.PLT

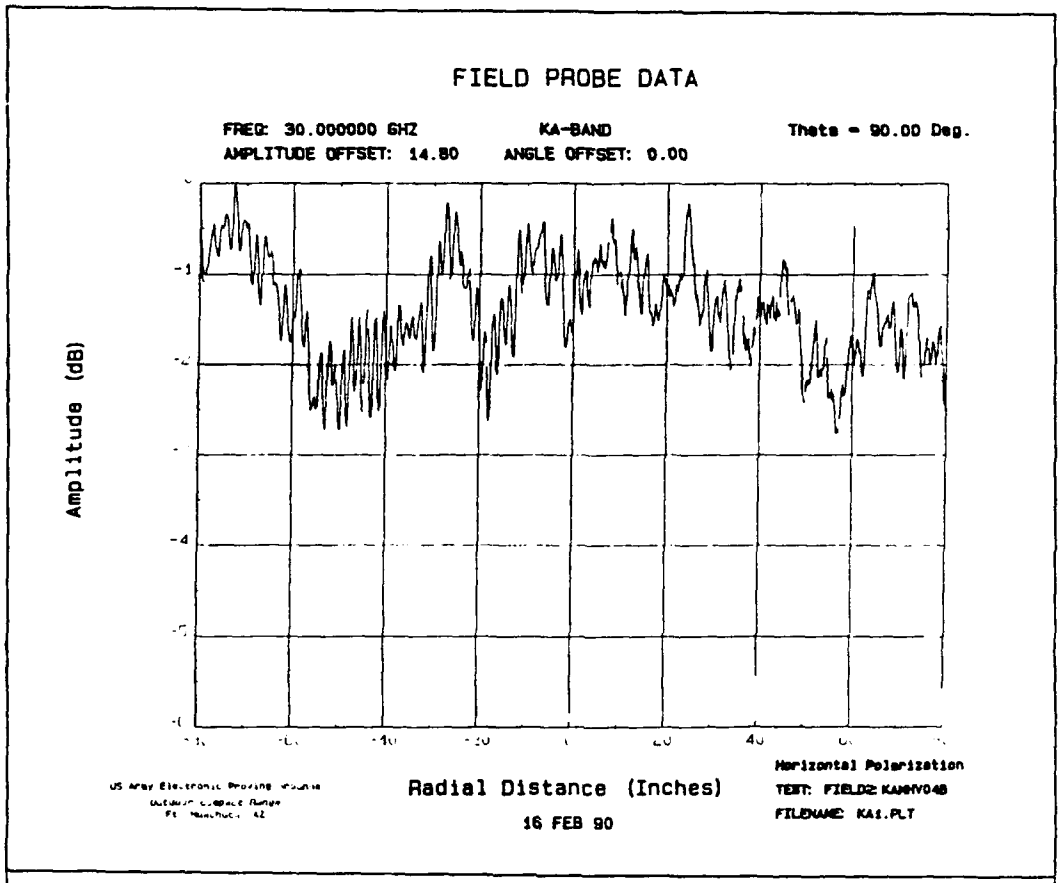

FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 16.17
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2: KAMVV04C
FILENAME: KA3.PLT
FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -148.12
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2: KAMVV04C
FILENAME: KA8.PLT

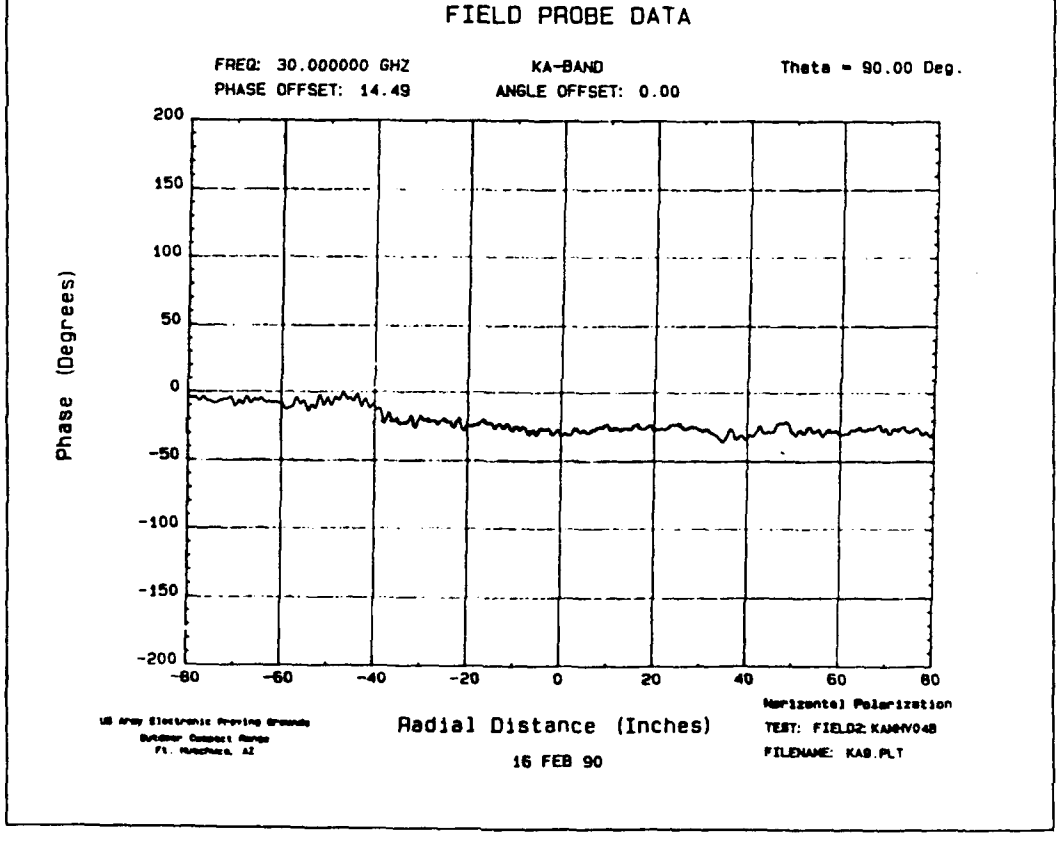

FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -148.12
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Vertical Polarization
TEST: FIELD2 KAHVV04C
FILENAME: MARK1N.PLT
FIELD PROBE DATA
FREQ: 40.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 18.34
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAHVV04D
FILENAME: MA3.PLT

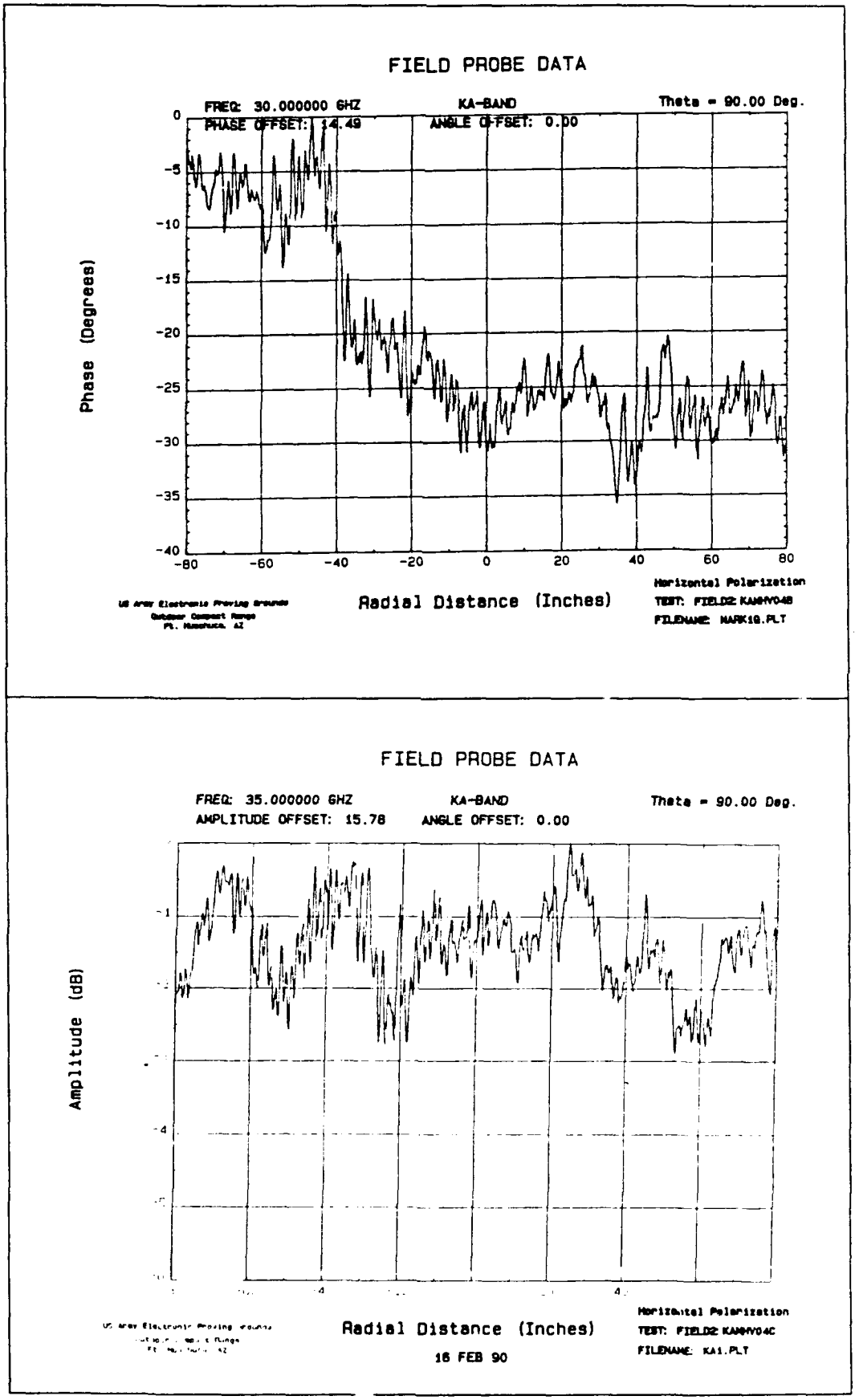

FIELD PROBE DATA
FREQ: 40.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -206.64
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Vertical Polarization
TEST: FIELD2 KAMVV04D
FILENAME: KA8.PLT
FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 14.86
ANGLE OFFSET: 0.00
Amplitude (dB)
-1
-4
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 KAMHV04A
FILENAME: KA1.PLT

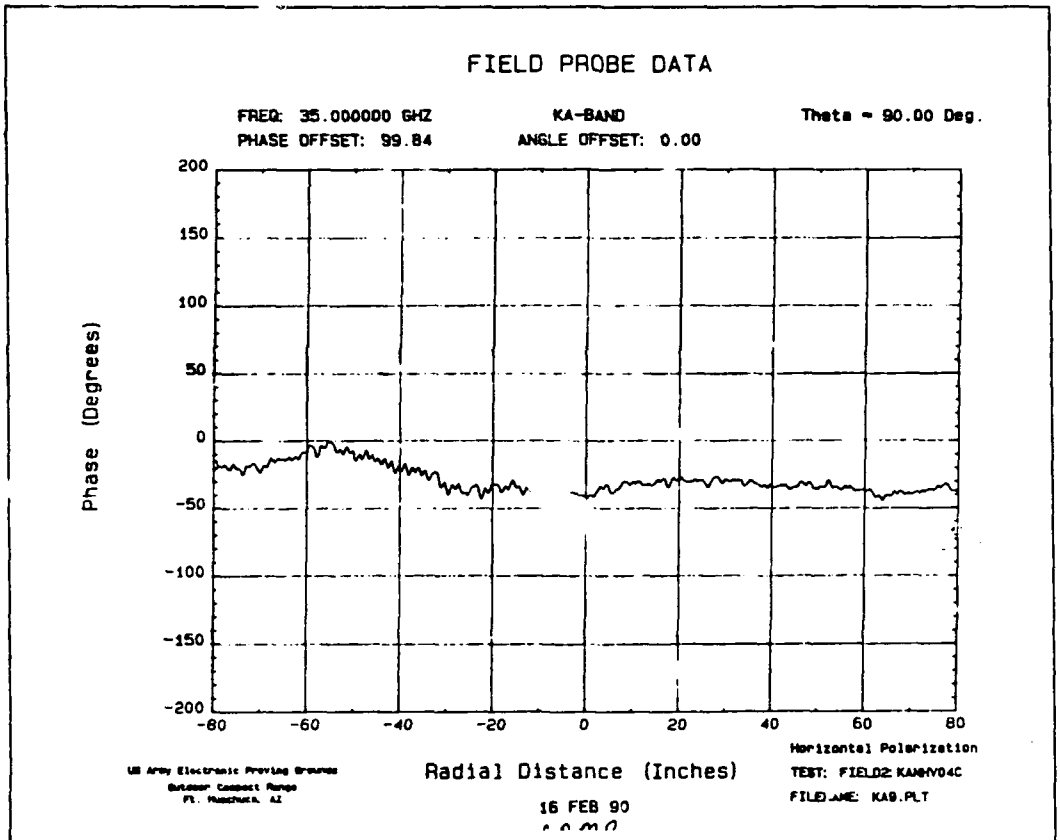

FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 85.62
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2: KA89V04A
FILENAME: KA9.PLT

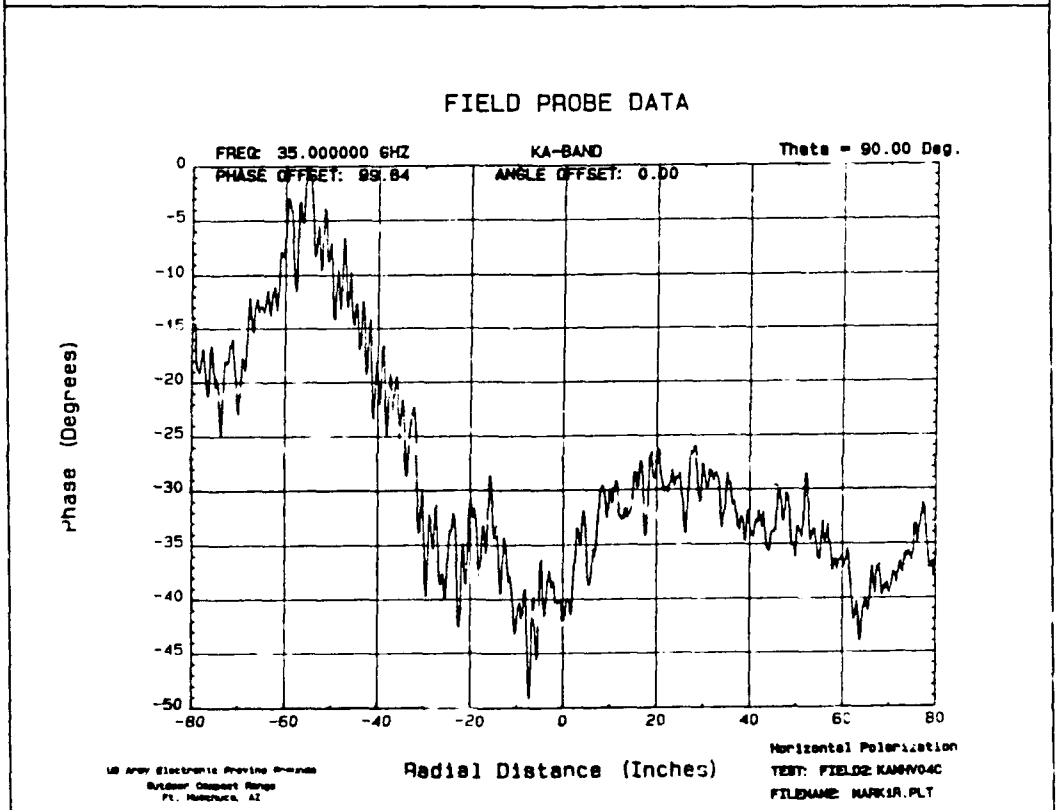

FIELD PROBE DATA
FREQ: 26.500010 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 85.62
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2: KA89V04A
FILENAME: MARK1P.PLT

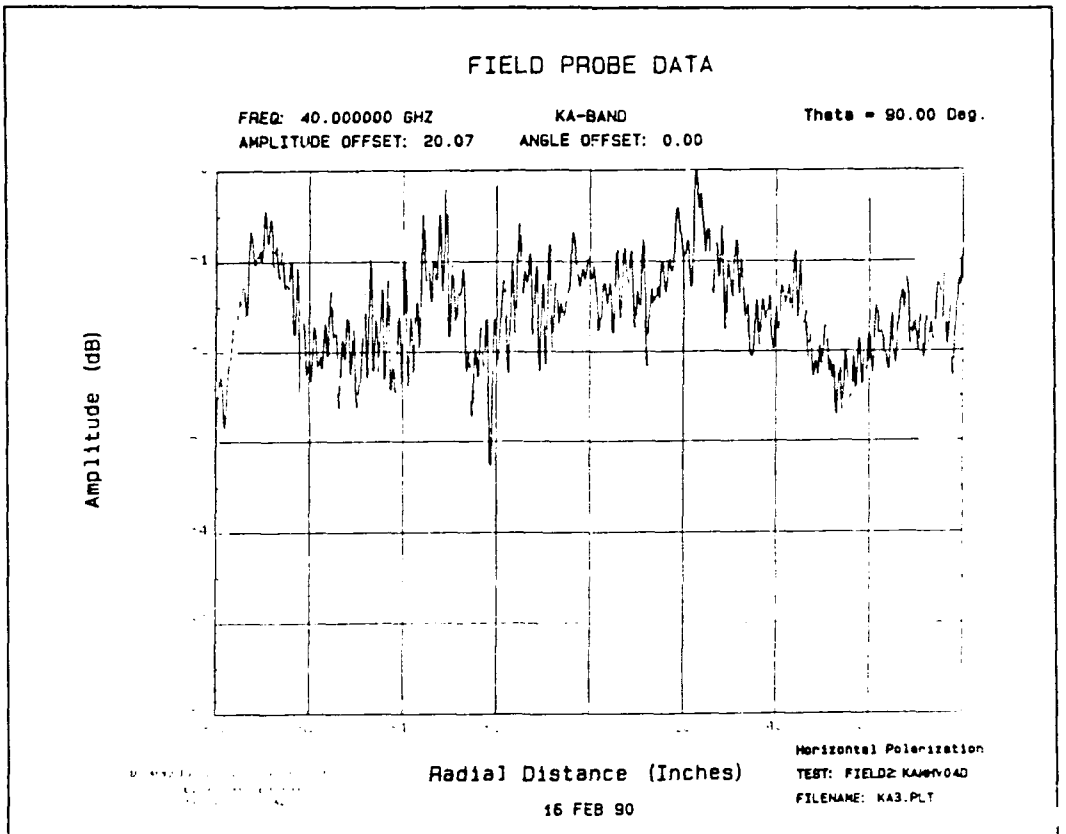

FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 14.80
ANGLE OFFSET: 0.00
Amplitude (dB)
-1
-2
-4
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 KAHV04B
FILENAME: KA1.PLT

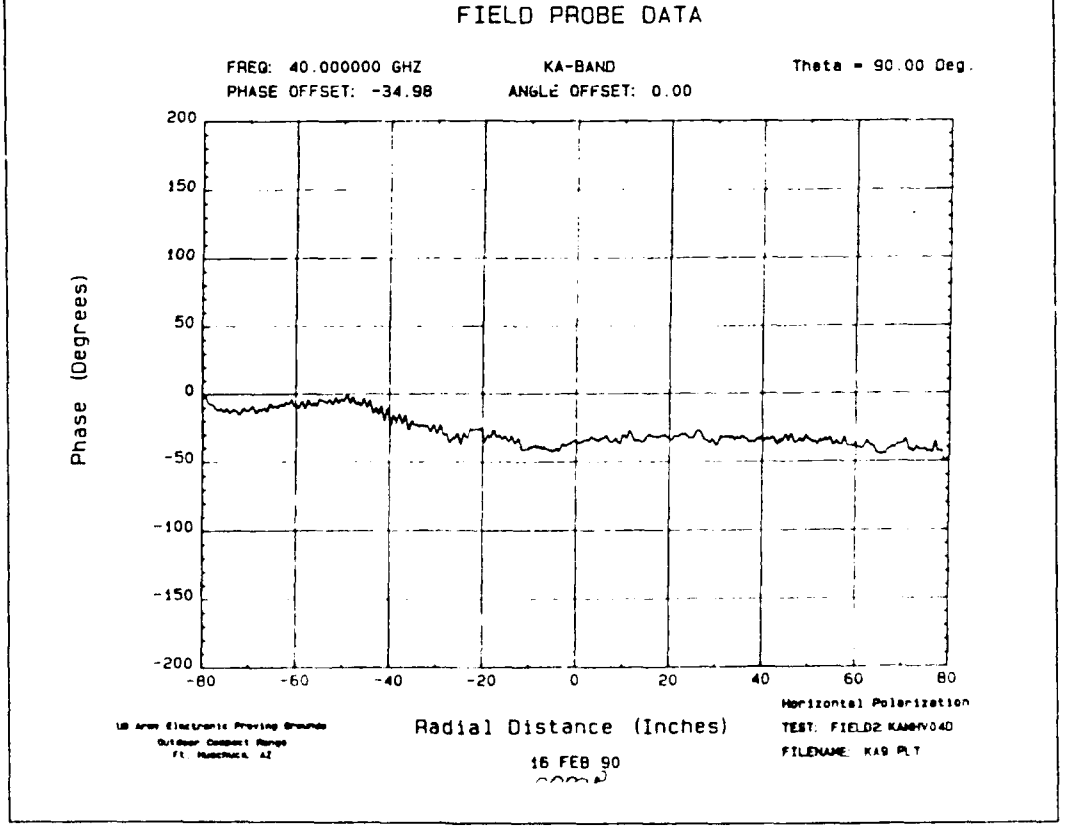

FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 14.49
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 KAHV04B
FILENAME: KA9.PLT

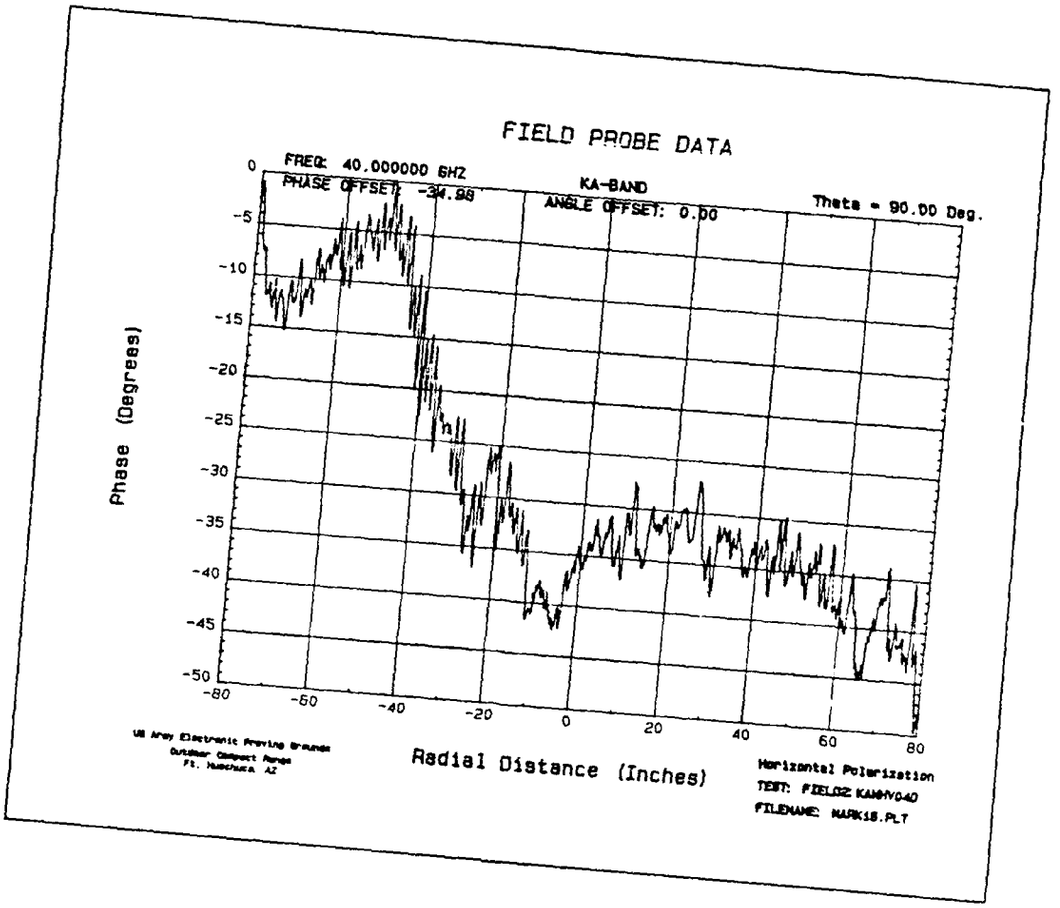

FIELD PROBE DATA
FREQ: 30.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 14.49
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KA6HV04B
FILENAME: MARK10.PLT
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca, AZ
FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 15.78
ANGLE OFFSET: 0.00
Amplitude (dB)
-1
-4
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 KA6HV04C
FILENAME: KA1.PLT


FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 99.84
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KA8HV04C
FILENAME: KA8.PLT
16 FEB 90


FIELD PROBE DATA
FREQ: 35.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: 99.84
ANGLE OFFSET: 0.00
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
Horizontal Polarization
TEST: FIELD2 KA8HV04C
FILENAME: MARK1R.PLT


FIELD PROBE DATA
FREQ: 40.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
AMPLITUDE OFFSET: 20.07
ANGLE OFFSET: 0.00
Amplitude (dB)
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 KAHV040
FILENAME: KA3.PLT


FIELD PROBE DATA
FREQ: 40.000000 GHZ
KA-BAND
Theta = 90.00 Deg.
PHASE OFFSET: -34.98
ANGLE OFFSET: 0.00
Phase (Degrees)
200
150
100
50
0
-50
-100
-150
-200
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
16 FEB 90
Horizontal Polarization
TEST: FIELD2 KAHV040
FILENAME: KA9.PLT


FIELD PROBE DATA
FREQ: 40.000000 GHZ
PHASE OFFSET: -34.98
KA-BAND
ANGLE OFFSET: 0.00
Theta = 90.00 Deg.
Phase (Degrees)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-80
-60
-40
-20
0
20
40
60
80
Radial Distance (Inches)
US Army Electronic Proving Grounds
Outdoor Compact Range
Ft. Huachuca AZ
Horizontal Polarization
TEST: FIELD2 KAHV040
FILENAME: MARK18.PLT

APPENDIX C. STANDARD GAIN HORN ANTENNA PATTERN MEASUREMENTS

C Band, 6 to 8 GHz ..... C- 3
X Band, 8 to 12.4 GHz ..... C- 8
Ku Band, 12.4 to 18 GHz C-16
K Band, 18 to 26.5 GHz C-19
Ka Band, 26.5 to 40 GHz C-24

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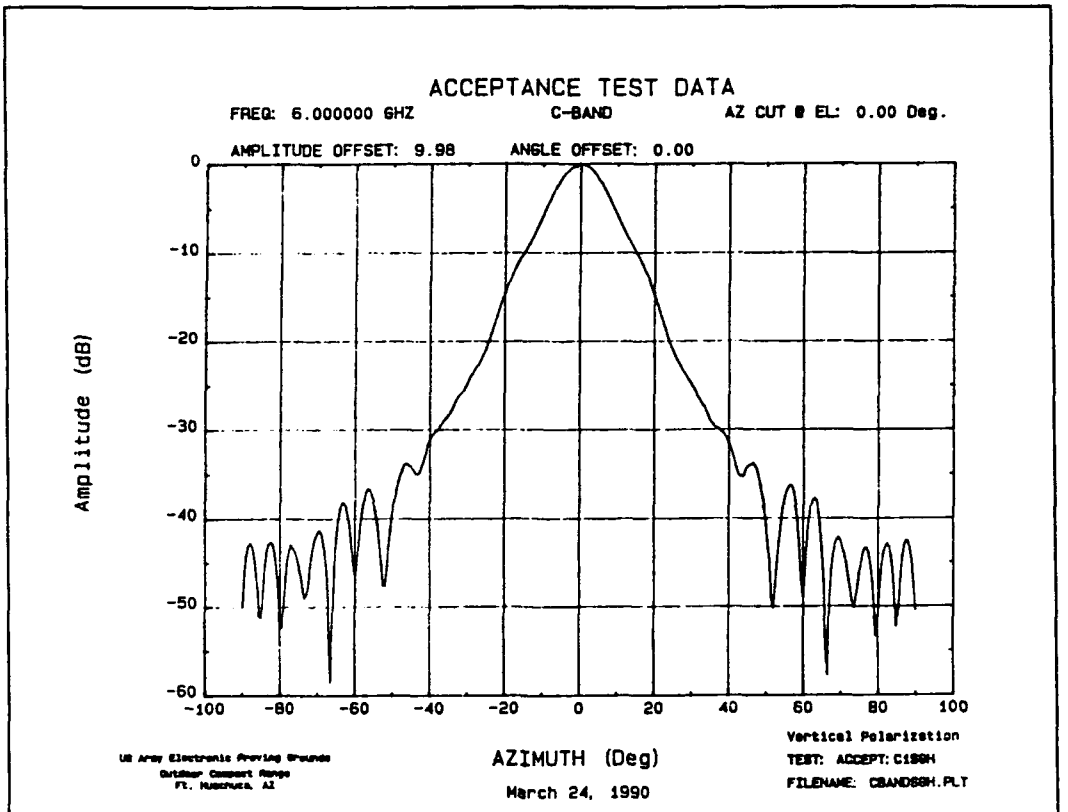
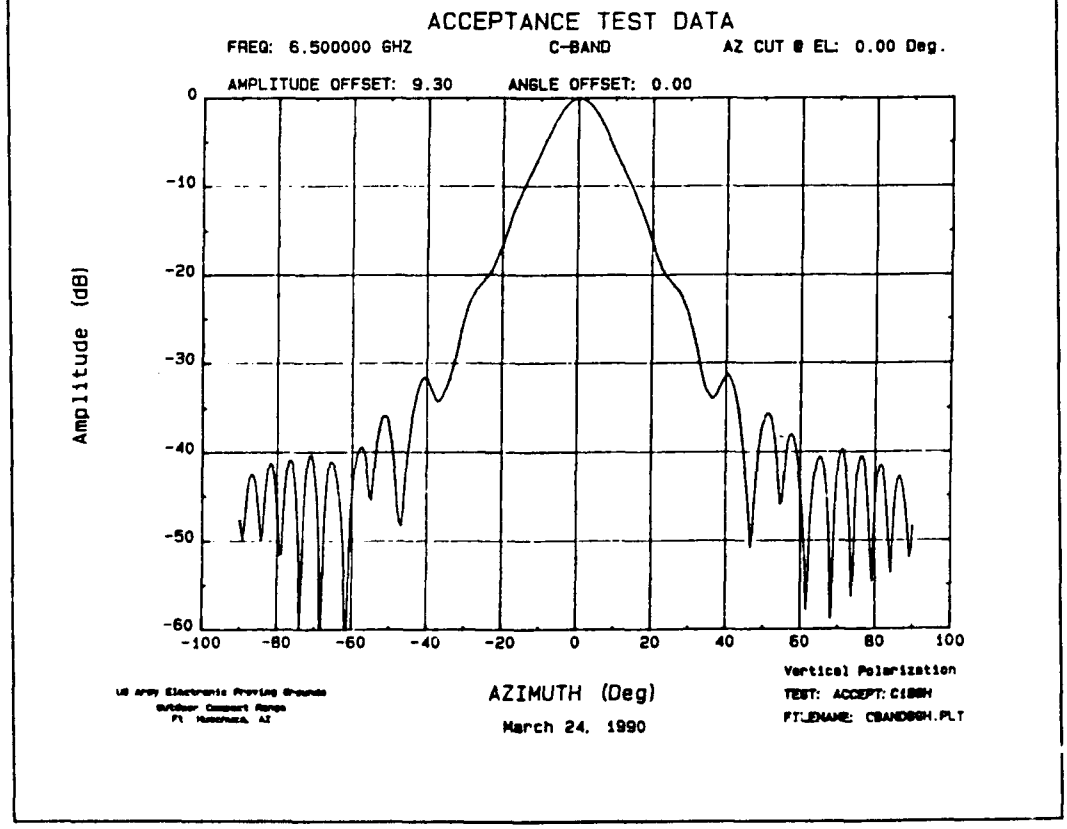
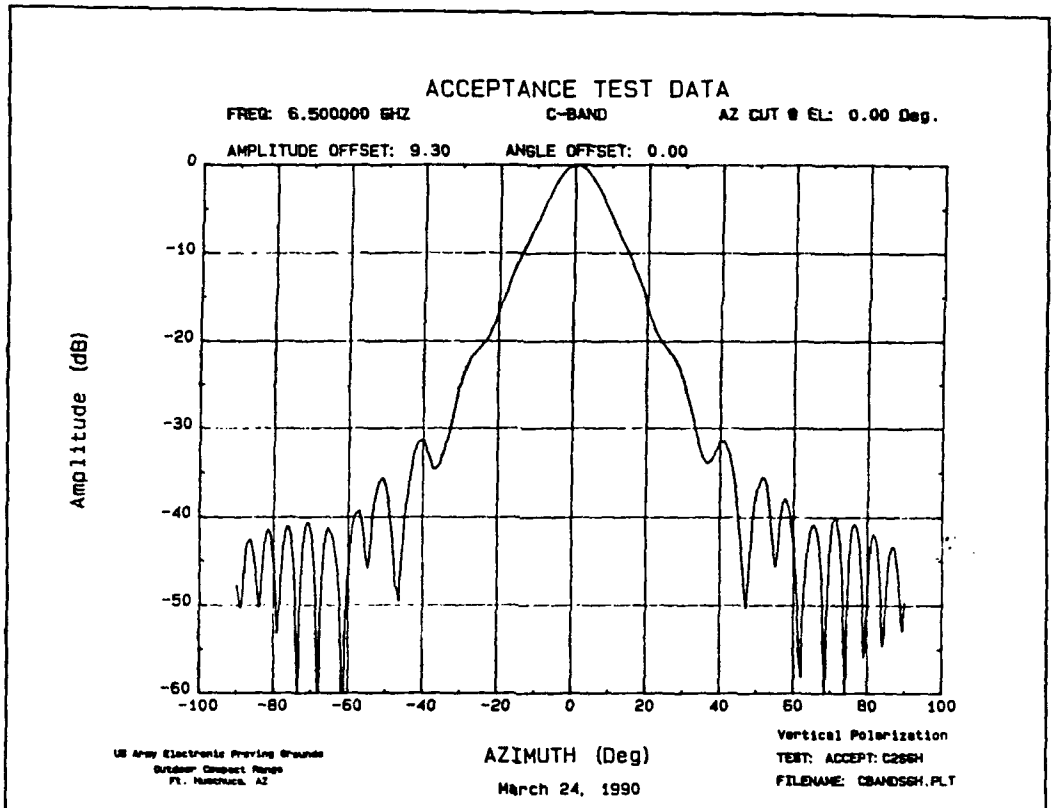
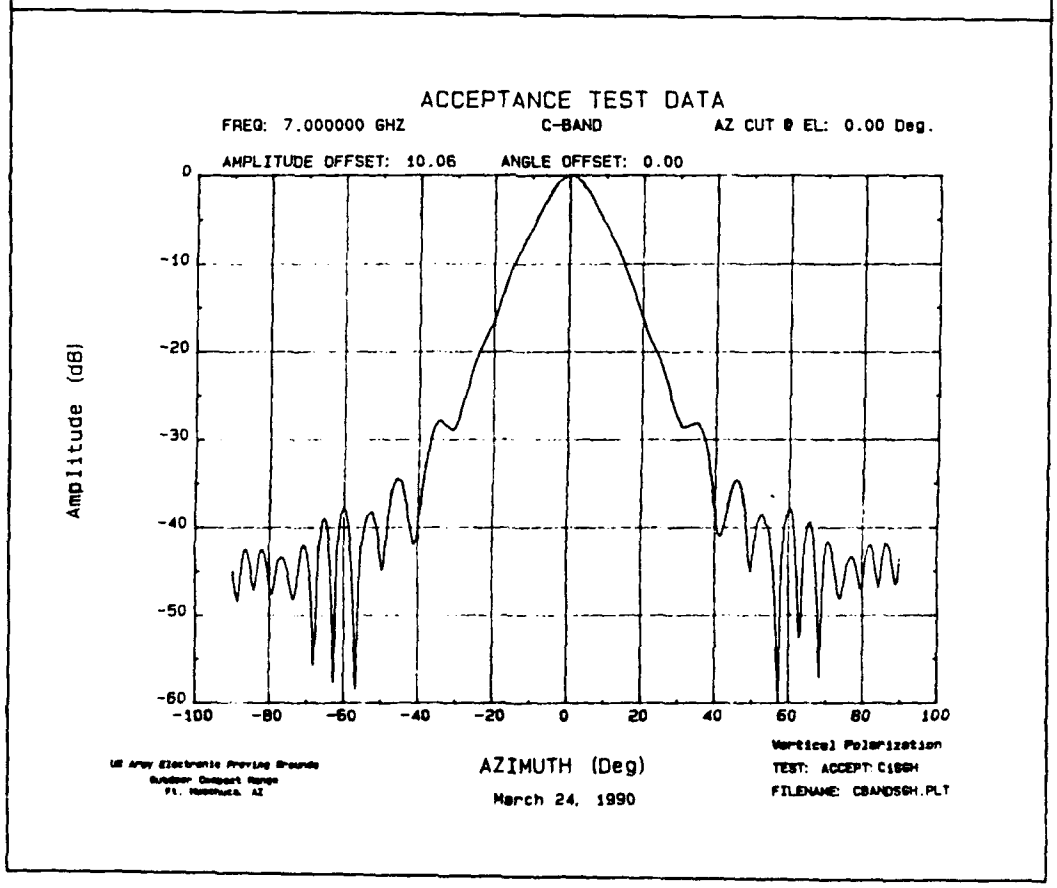
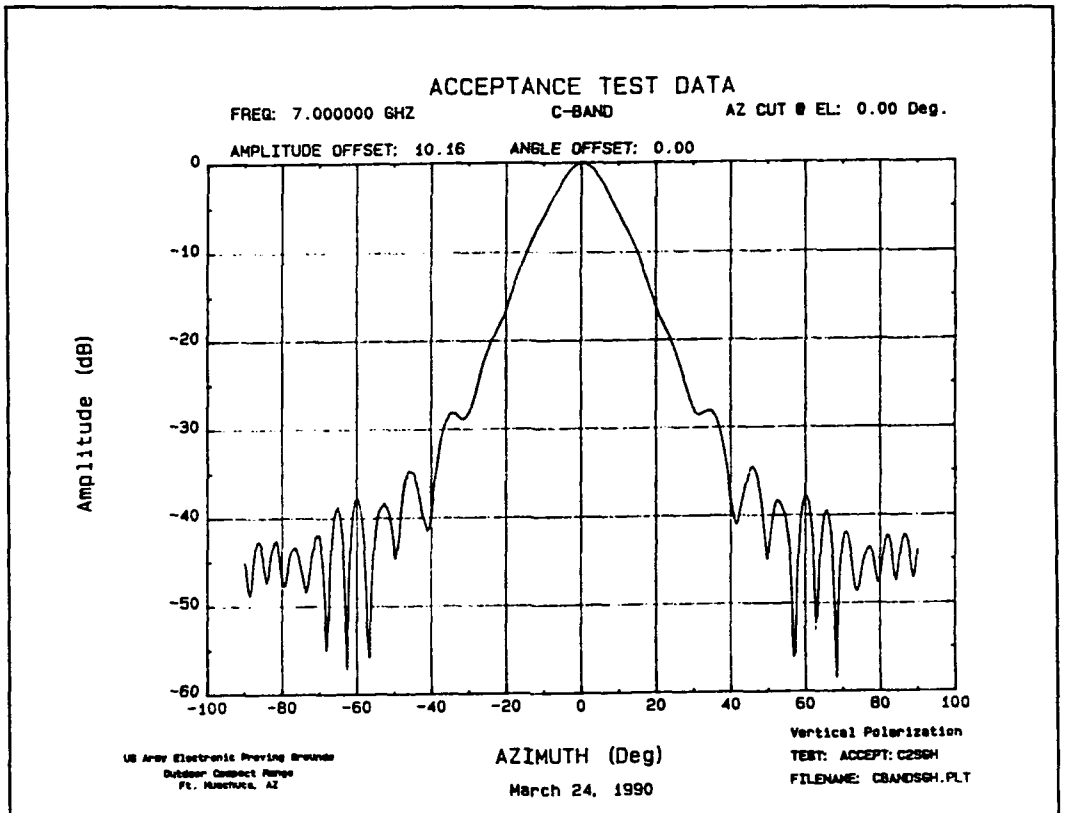
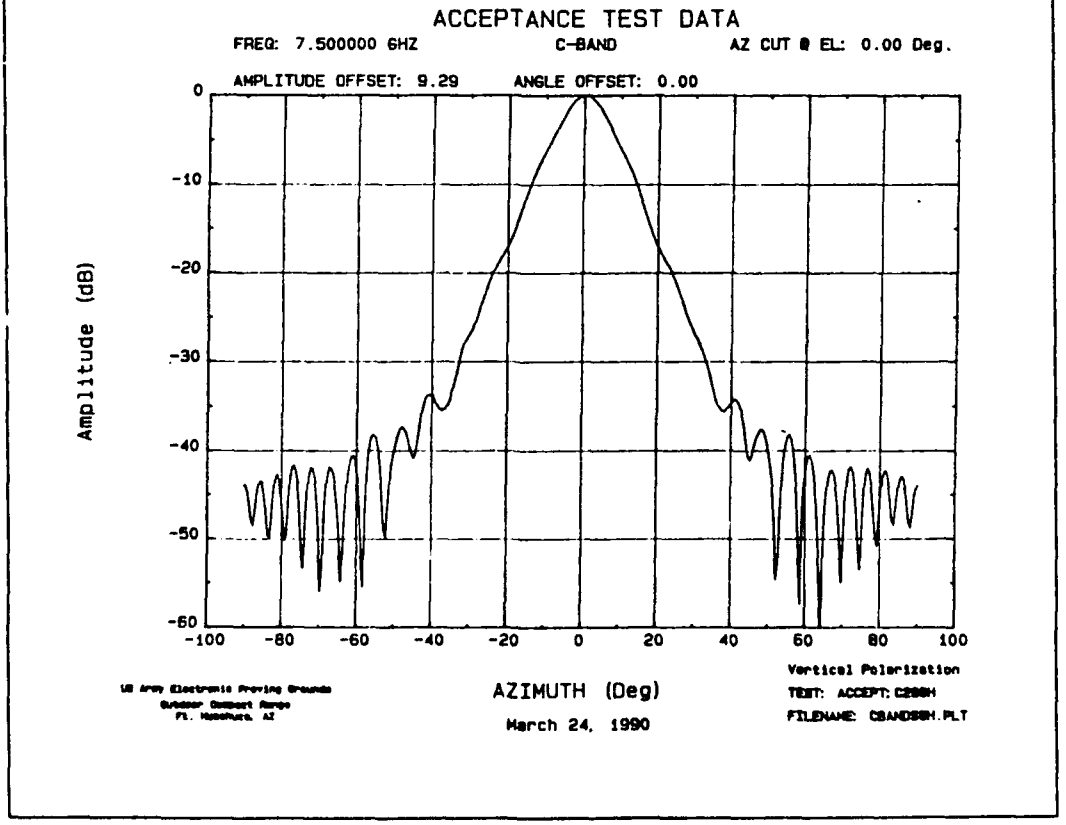

ACCEPTANCE TEST DATA
FREQ: 6.000000 GHZ
C-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 9.98
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24, 1990
Vertical Polarization
TEST: ACCEPT:C1SGH
FILENAME: CBANDSGH.PLT

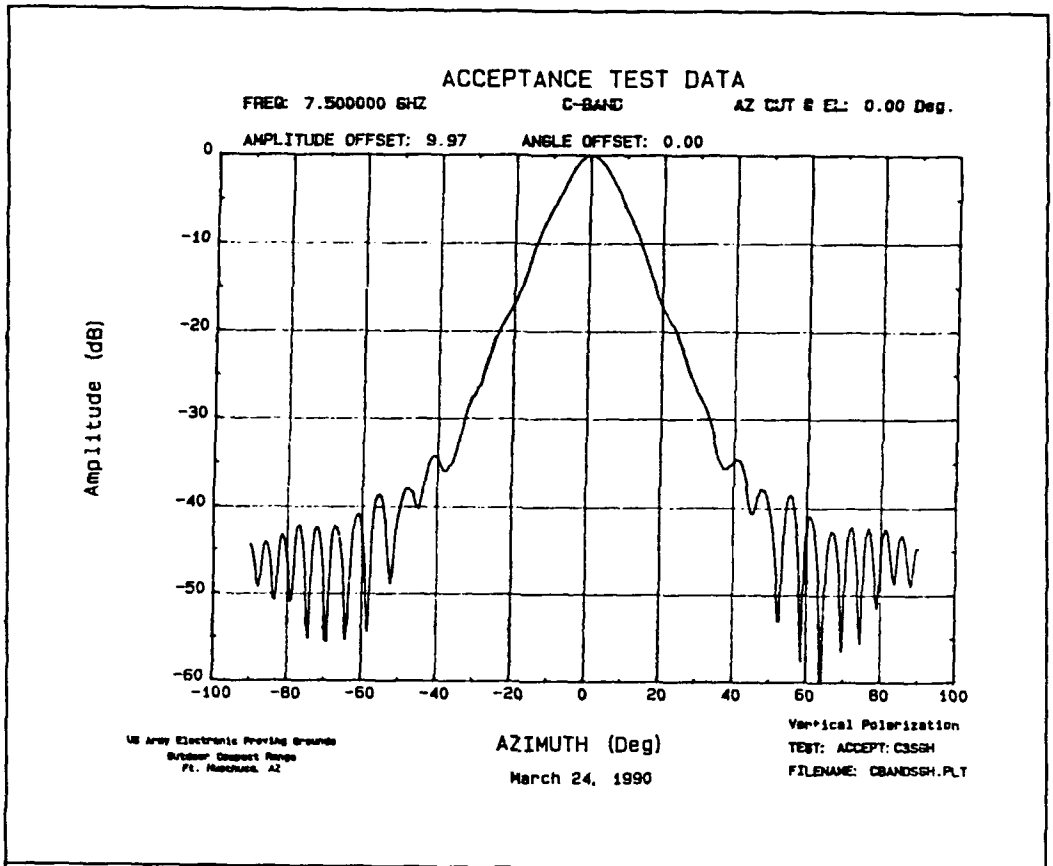

ACCEPTANCE TEST DATA
FREQ: 6.500000 GHZ
C-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 9.30
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24, 1990
Vertical Polarization
TEST: ACCEPT:C1SGH
FILENAME: CBANDSGH.PLT

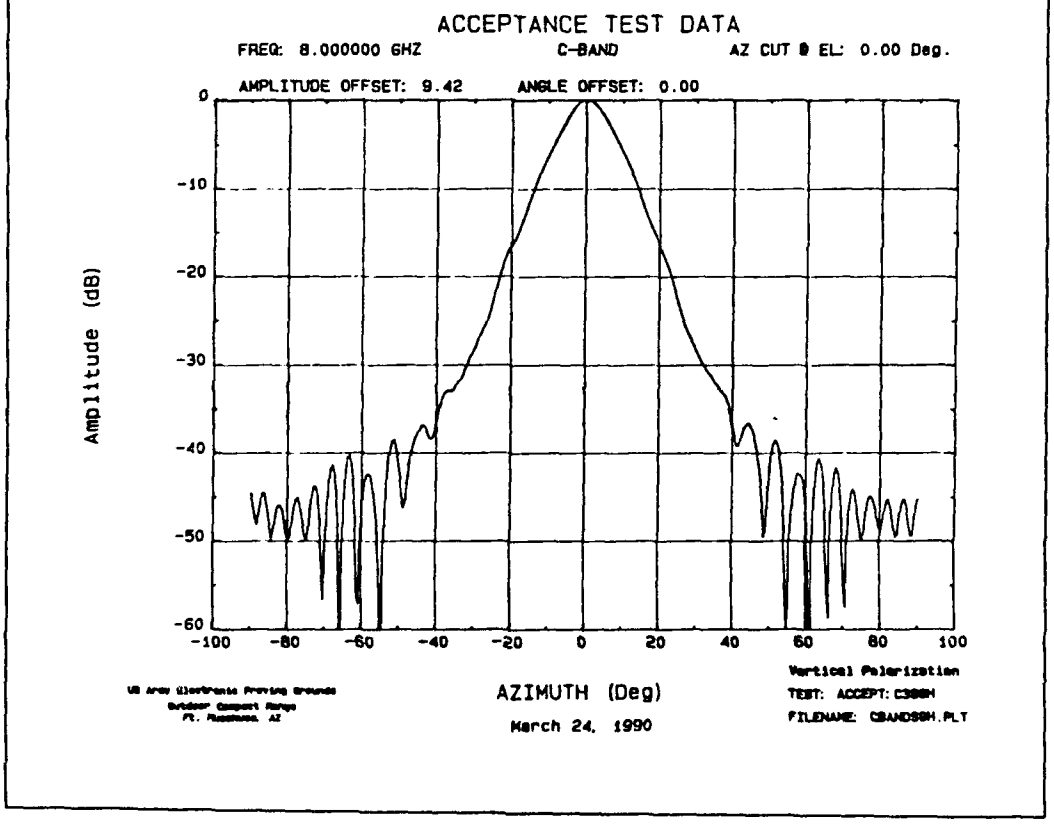

ACCEPTANCE TEST DATA
FREQ: 6.500000 GHZ
C-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 9.30
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24, 1990
Vertical Polarization
TEST: ACCEPT: C2SGH
FILENAME: CBANDSGH.PLT

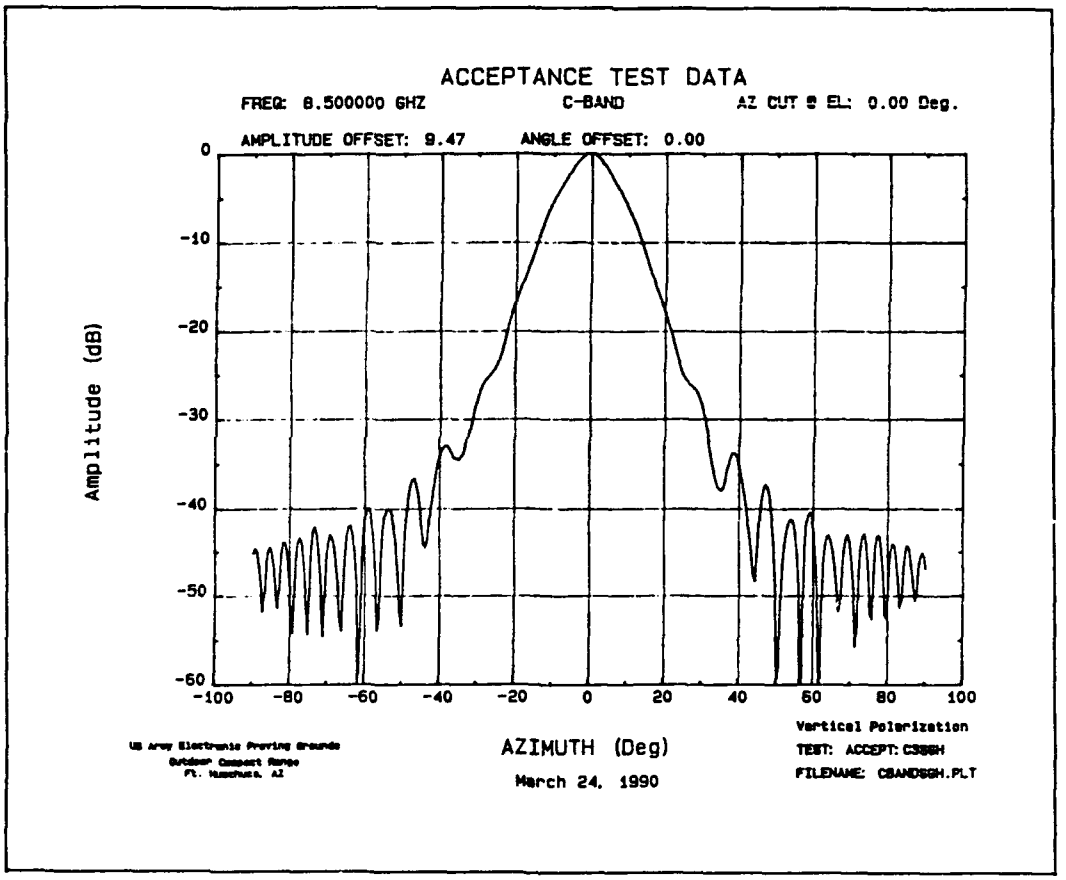

ACCEPTANCE TEST DATA
FREQ: 7.000000 GHZ
C-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 10.06
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24, 1990
Vertical Polarization
TEST: ACCEPT: C1SGH
FILENAME: CBANDSGH.PLT

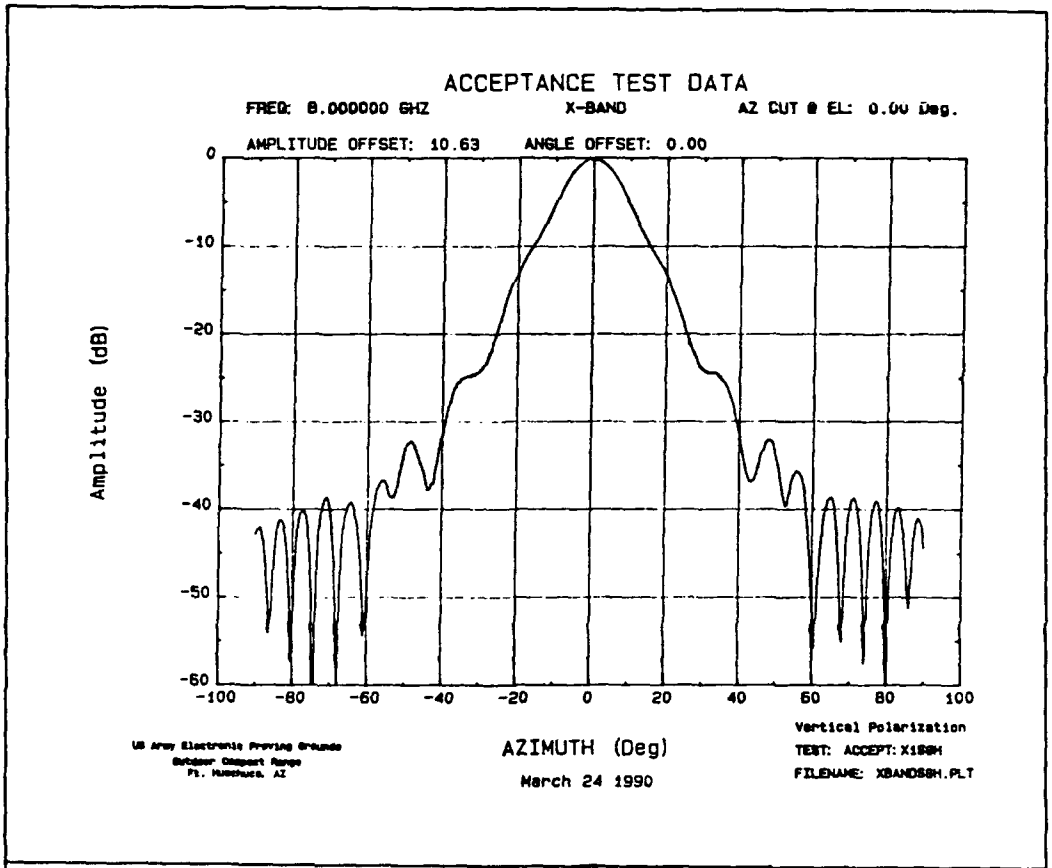

ACCEPTANCE TEST DATA
FREQ: 7.000000 GHZ
C-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 10.16
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24, 1990
Vertical Polarization
TEST: ACCEPT: C2SGH
FILENAME: CBANDSGH.PLT

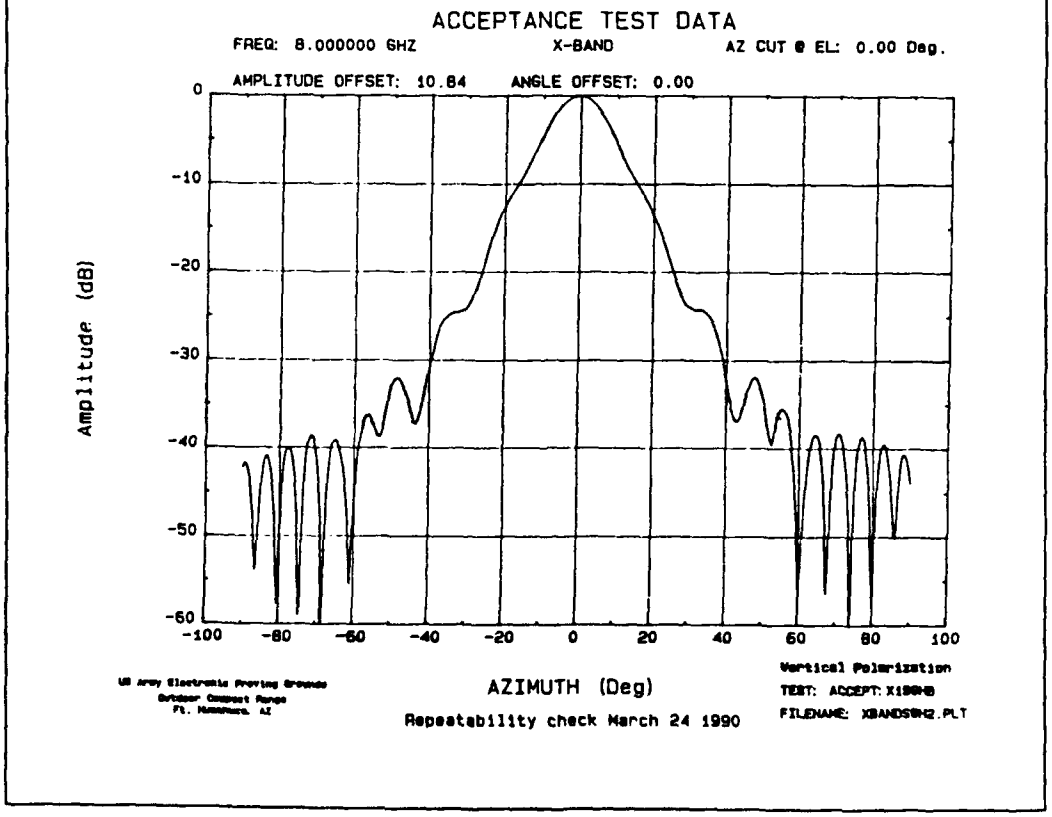

ACCEPTANCE TEST DATA
FREQ: 7.500000 GHZ
C-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 9.29
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24, 1990
Vertical Polarization
TEST: ACCEPT: C2SGH
FILENAME: CBANDSGH.PLT

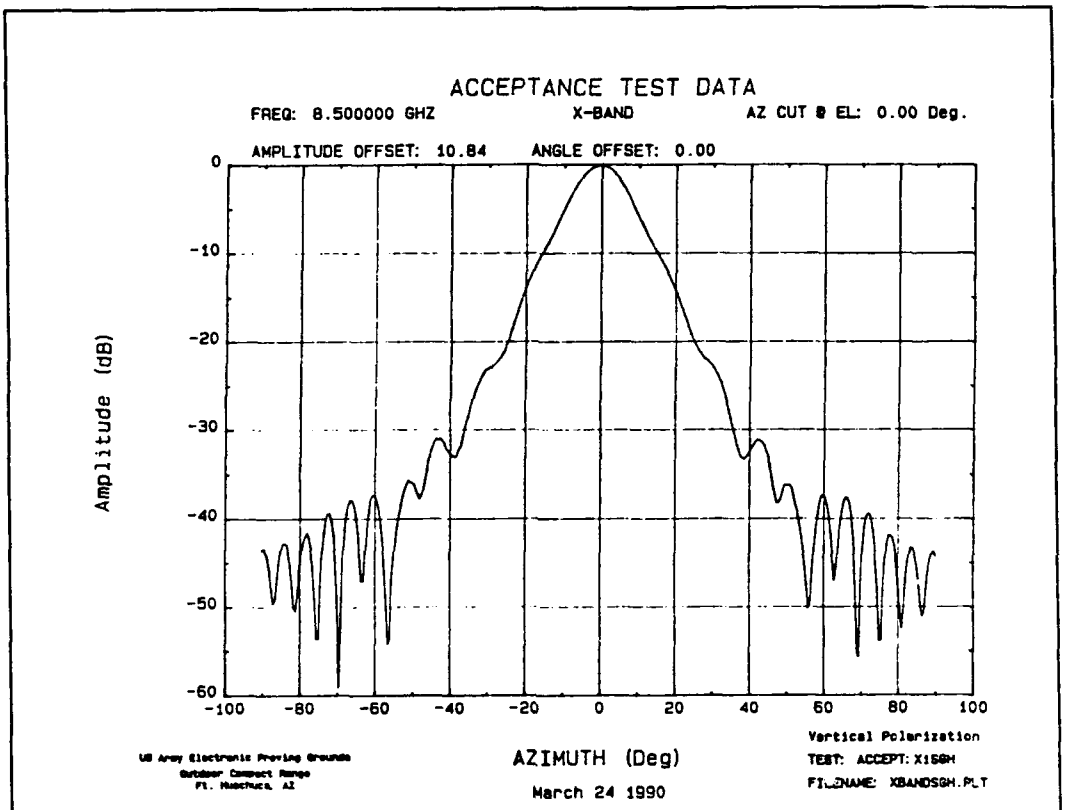

ACCEPTANCE TEST DATA
FREQ: 7.500000 GHZ
C-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 9.97
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24, 1990
Vertical Polarization
TEST: ACCEPT: C3SSH
FILENAME: CBANDSSH.PLT

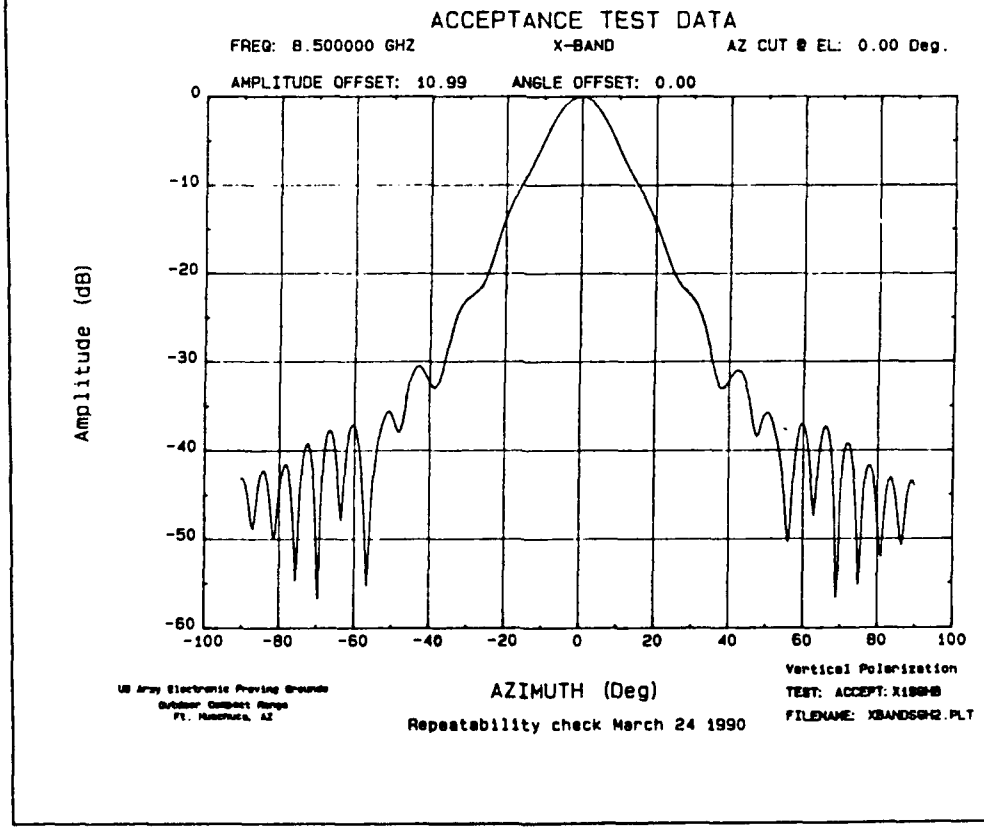

ACCEPTANCE TEST DATA
FREQ: 8.000000 GHZ
C-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 9.42
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24, 1990
Vertical Polarization
TEST: ACCEPT: C3SSH
FILENAME: CBANDSSH.PLT

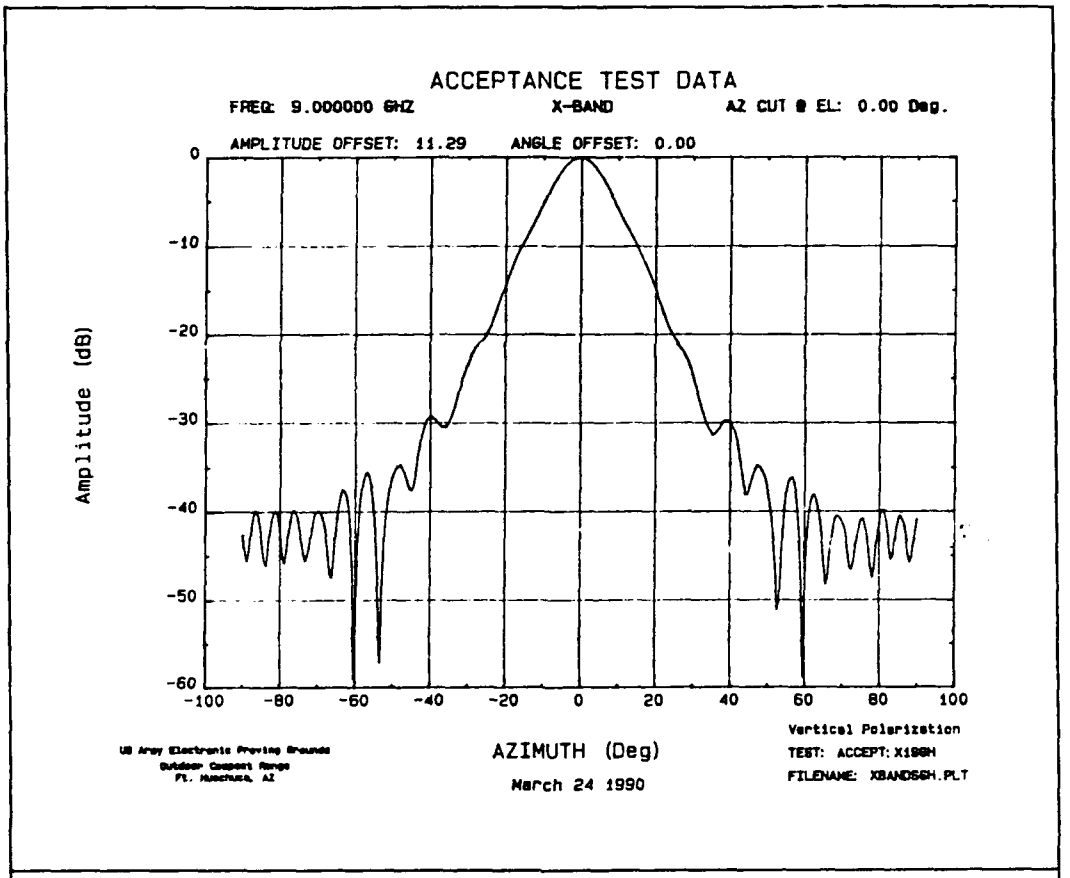

ACCEPTANCE TEST DATA
FREQ: 8.500000 GHZ
C-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 9.47
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24, 1990
Vertical Polarization
TEST: ACCEPT: CSSGH
FILENAME: CBANDSGH.PLT

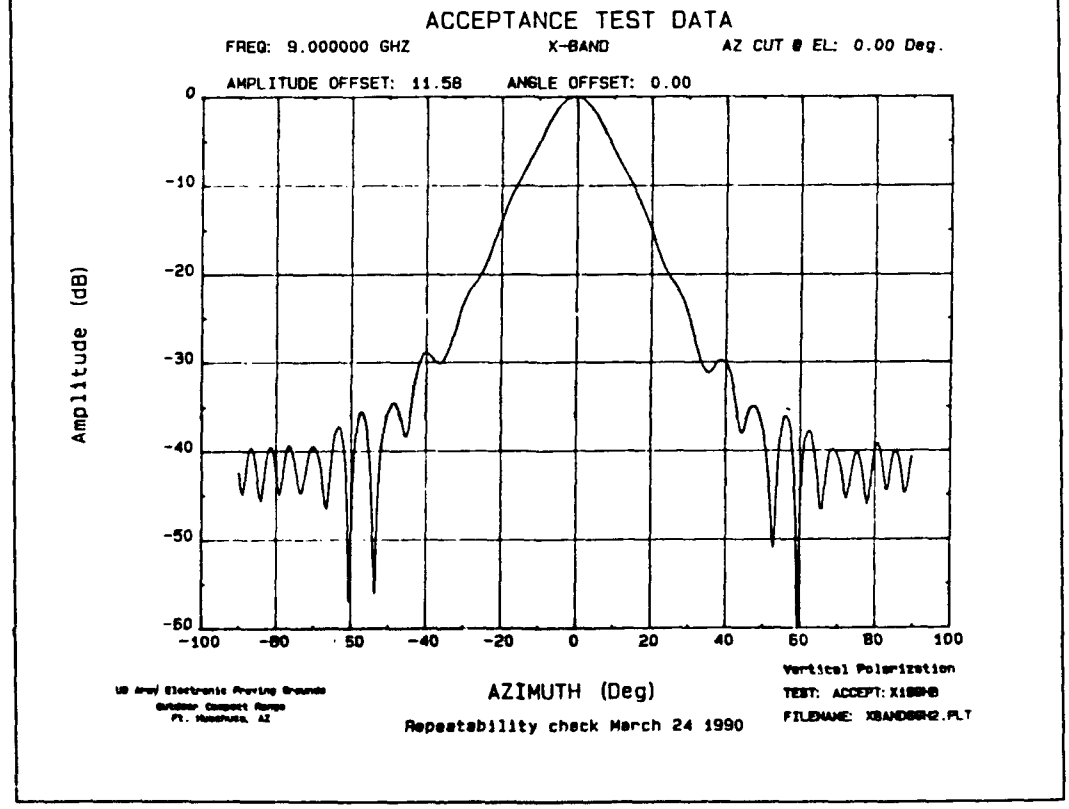

ACCEPTANCE TEST DATA
FREQ: 8.000000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 10.63
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X18SH
FILENAME: XBANDSSH.PLT

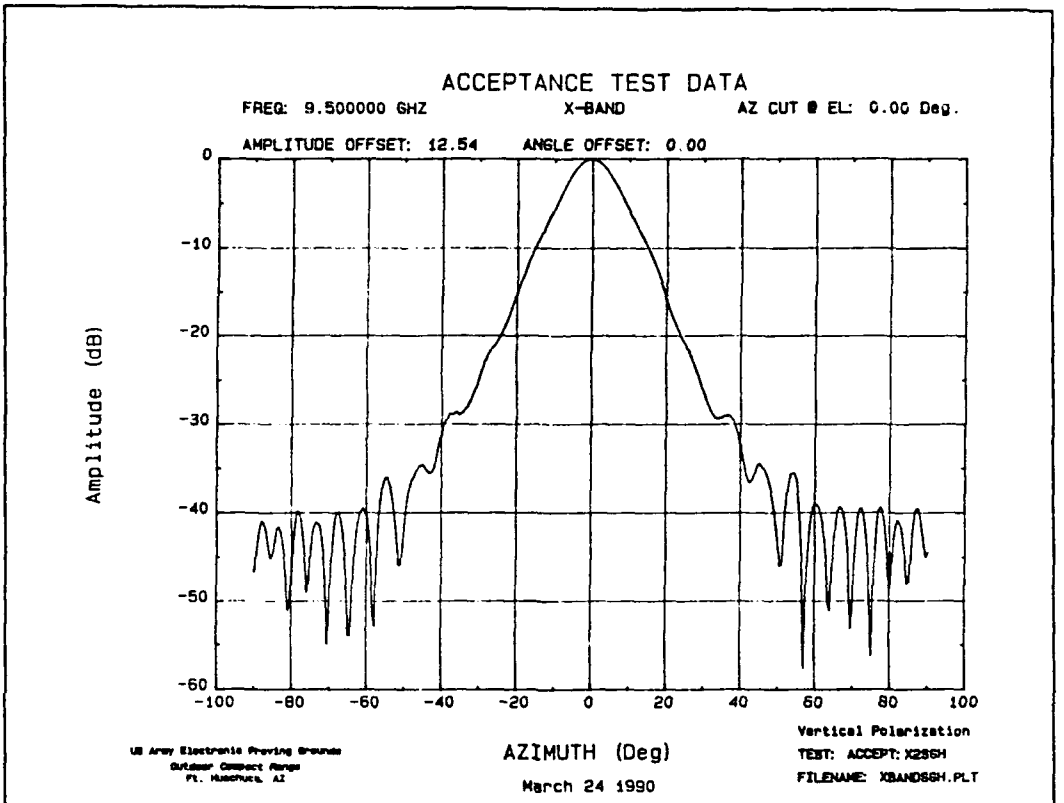

ACCEPTANCE TEST DATA
FREQ: 8.000000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 10.64
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
Repeatability check March 24 1990
Vertical Polarization
TEST: ACCEPT: X18HB
FILENAME: XBANDSHB2.PLT

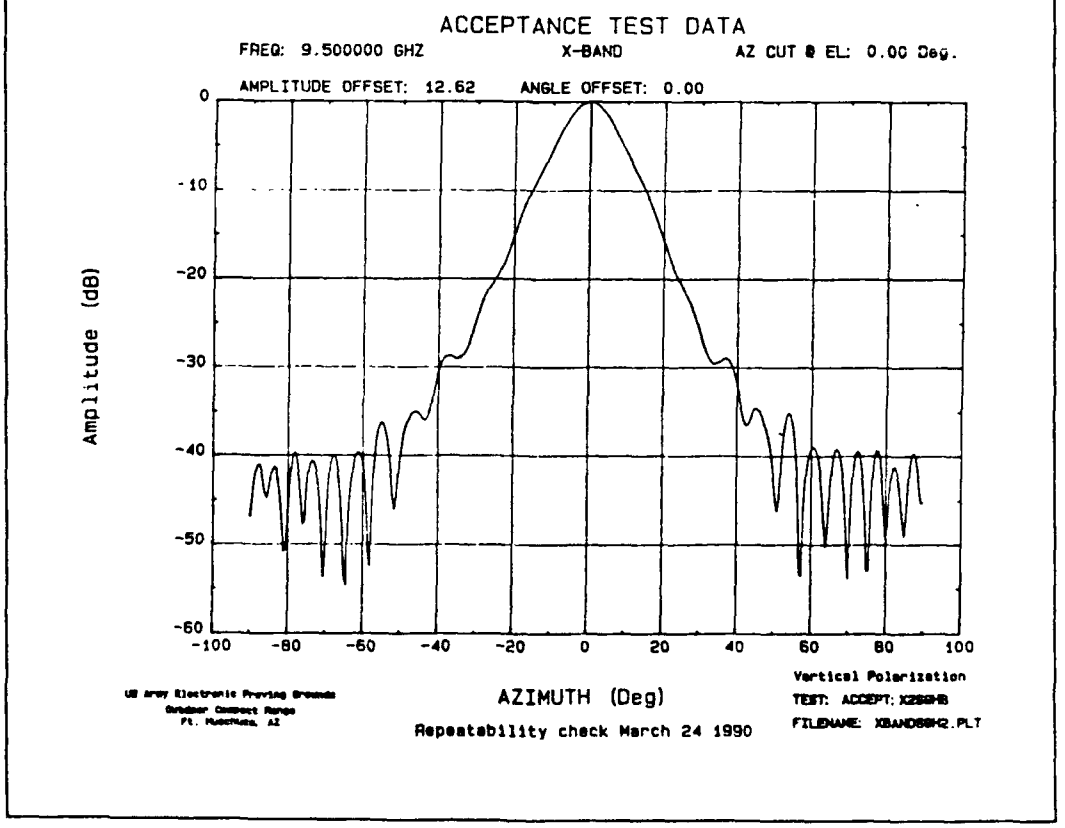

ACCEPTANCE TEST DATA
FREQ: 8.500000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 10.84
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X1SGH
FILENAME: XBANDSGH.PLT

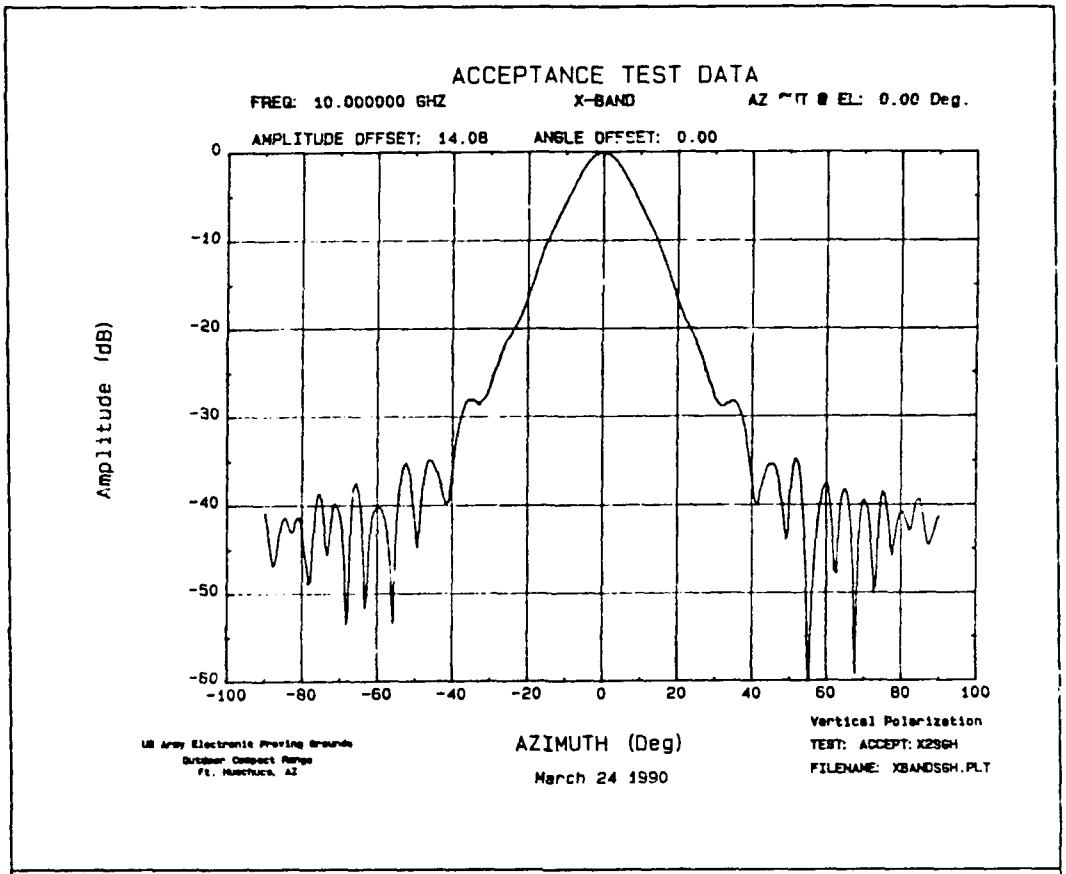

ACCEPTANCE TEST DATA
FREQ: 8.500000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 10.99
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
Repeatability check March 24 1990
Vertical Polarization
TEST: ACCEPT: X1SGHB
FILENAME: XBANDSGH2.PLT

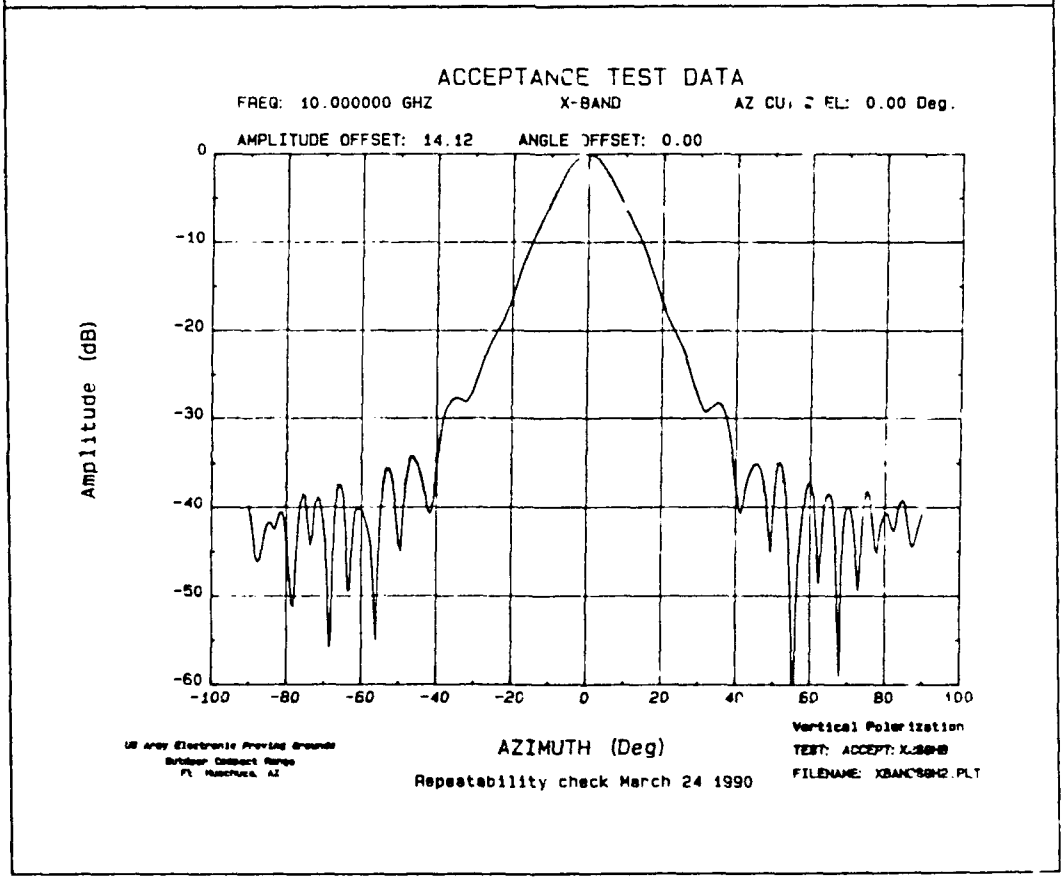

ACCEPTANCE TEST DATA
FREQ: 9.000000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 11.29
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X19SH
FILENAME: XBANDSSH.PLT

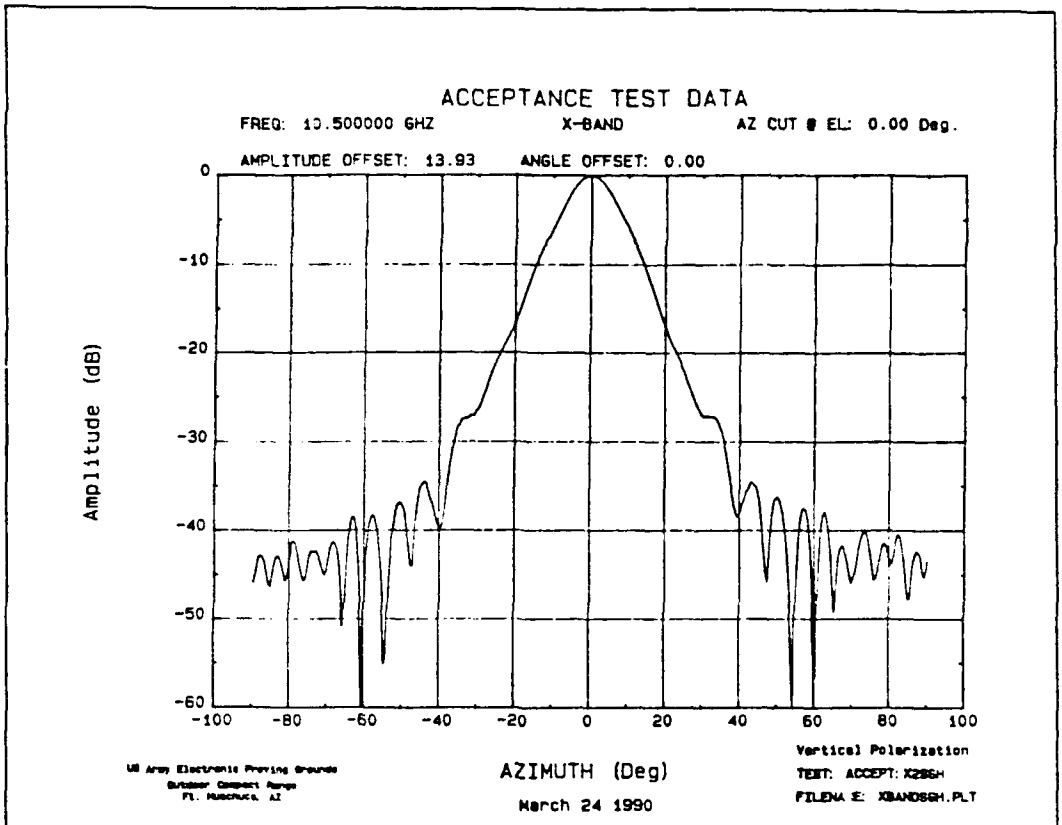

ACCEPTANCE TEST DATA
FREQ: 9.000000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 11.58
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-50
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
Repeatability check March 24 1990
Vertical Polarization
TEST: ACCEPT: X19SHB
FILENAME: XBANDSSH2.PLT

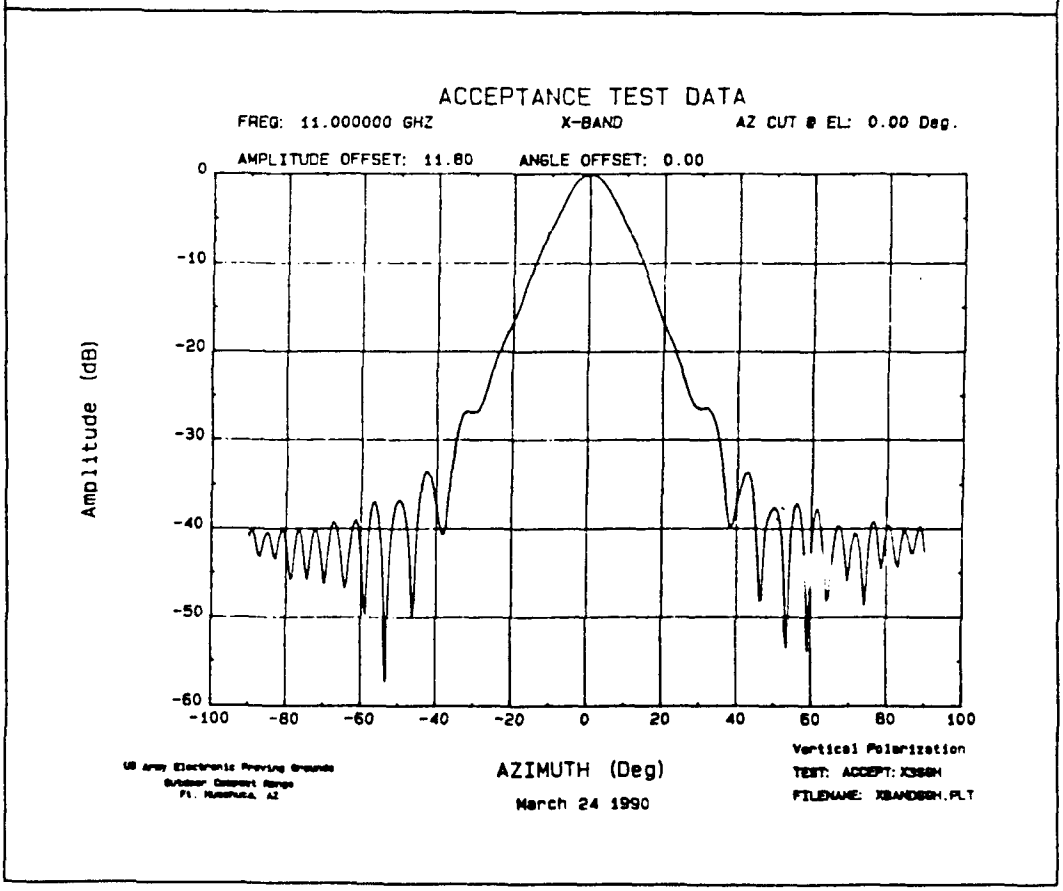

ACCEPTANCE TEST DATA
FREQ: 9.500000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 12.54
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X2SSH
FILENAME: XBANDSSH.PLT

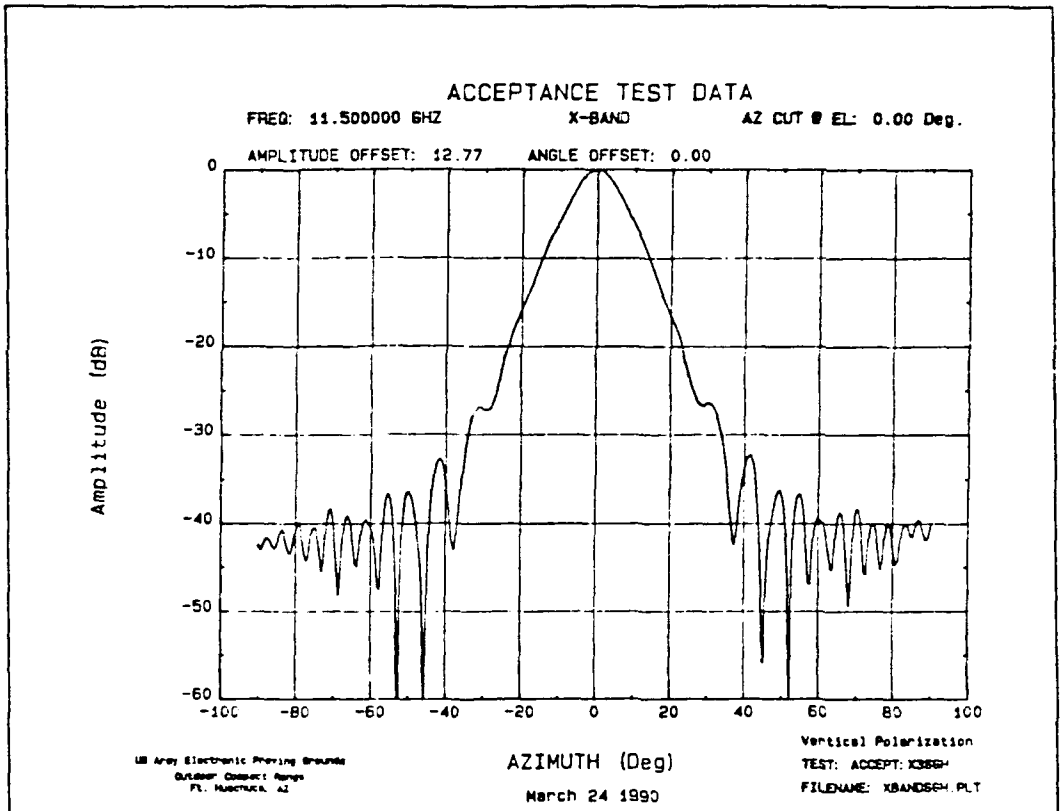

ACCEPTANCE TEST DATA
FREQ: 9.500000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 12.62
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
Repeatability check March 24 1990
Vertical Polarization
TEST: ACCEPT: X2SSHR
FILENAME: XBANDSSH2.PLT

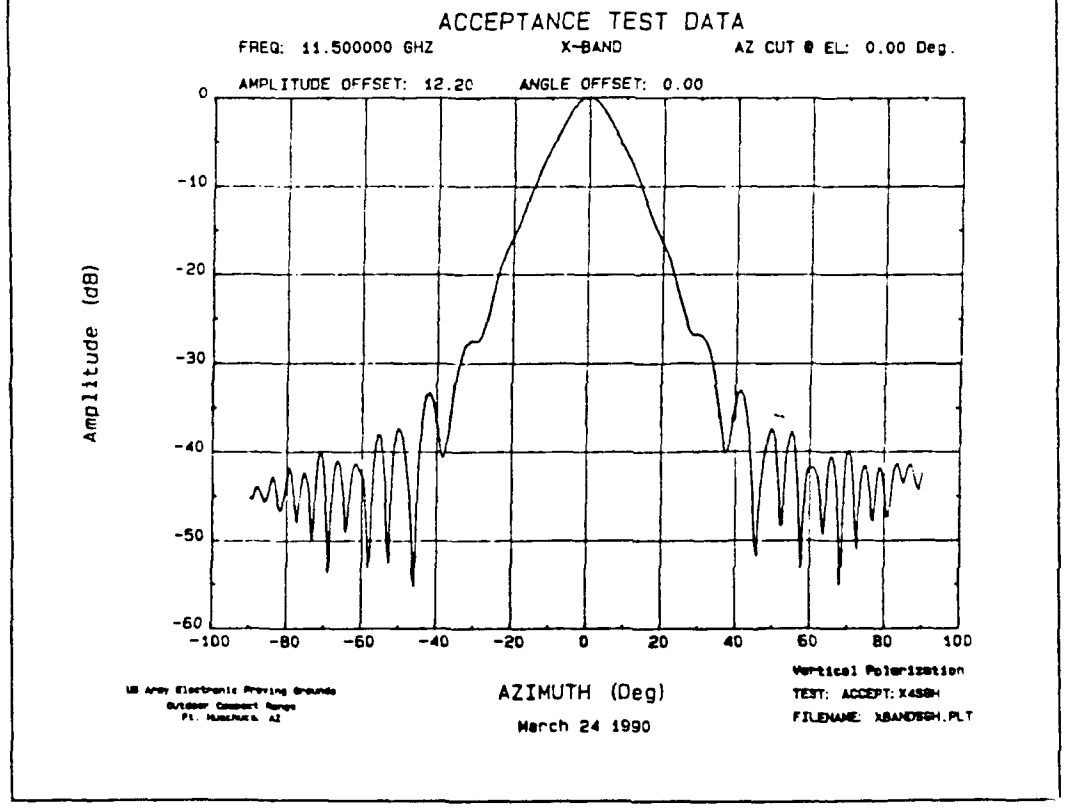

ACCEPTANCE TEST DATA
FREQ: 10.000000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 14.08
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X2SGH
FILENAME: XBANDSGH.PLT

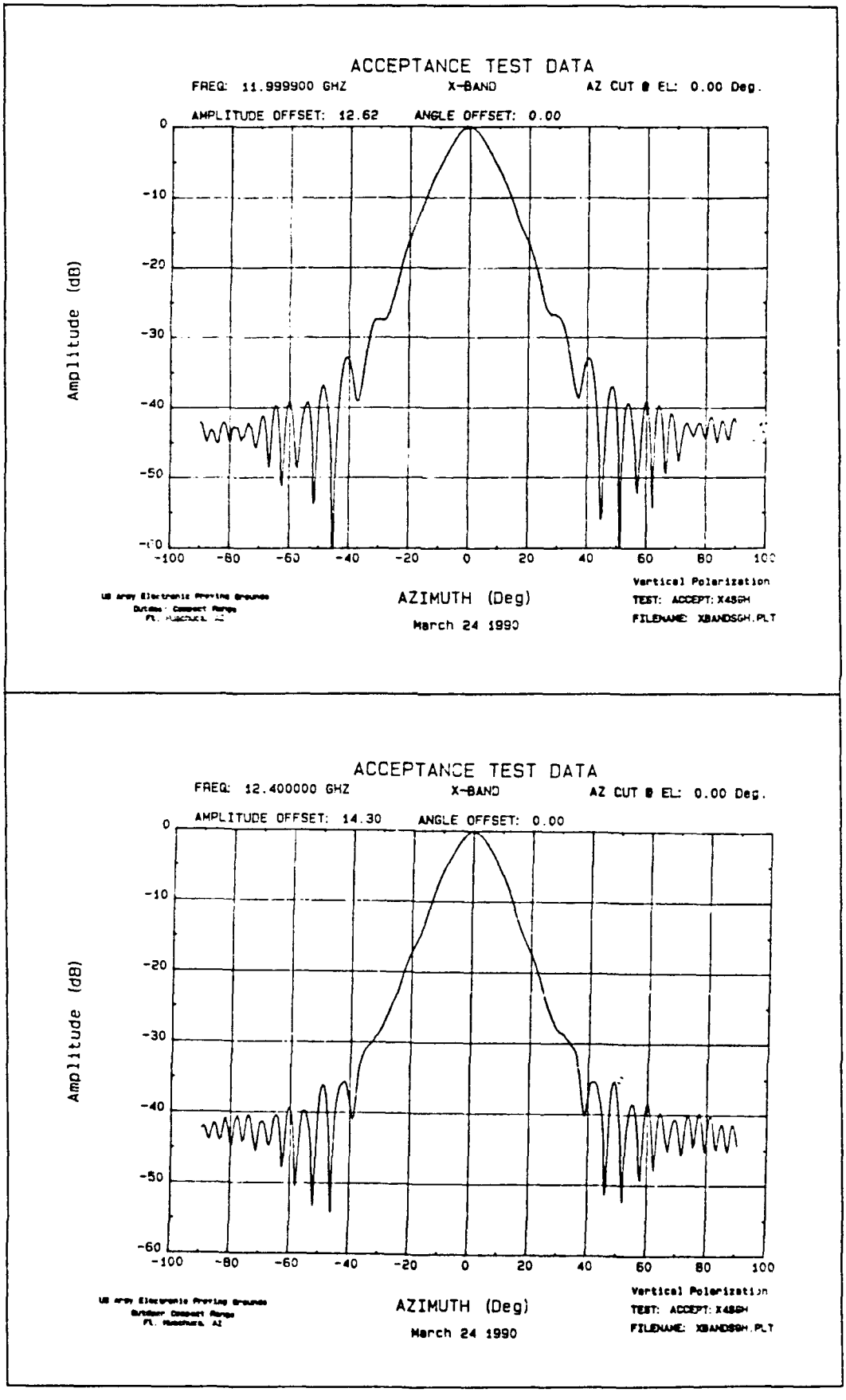

ACCEPTANCE TEST DATA
FREQ: 10.000000 GHZ
X-BAND
AMPLITUDE OFFSET: 14.12
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
60
80
100
AZIMUTH (Deg)
Repeatability check March 24 1990
Vertical Polarization

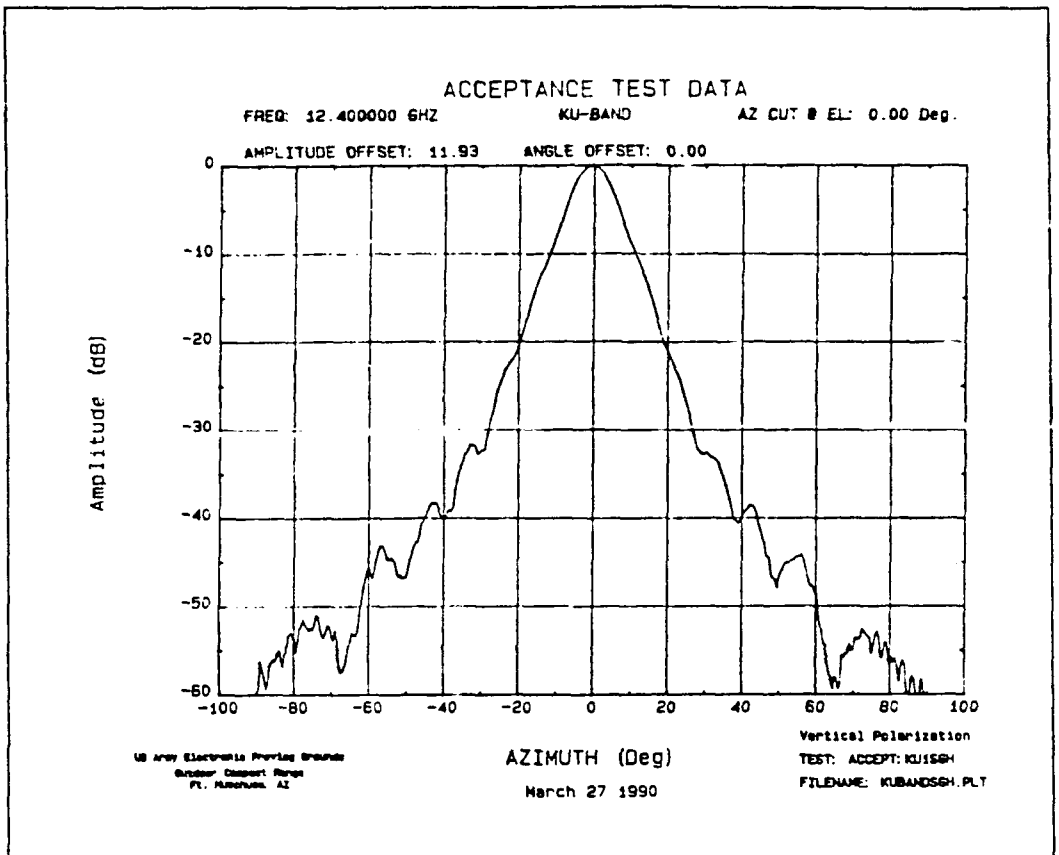

ACCEPTANCE TEST DATA
FREQ: 10.500000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 13.93
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X28SH
FILENAME: XBANDSSH.PLT

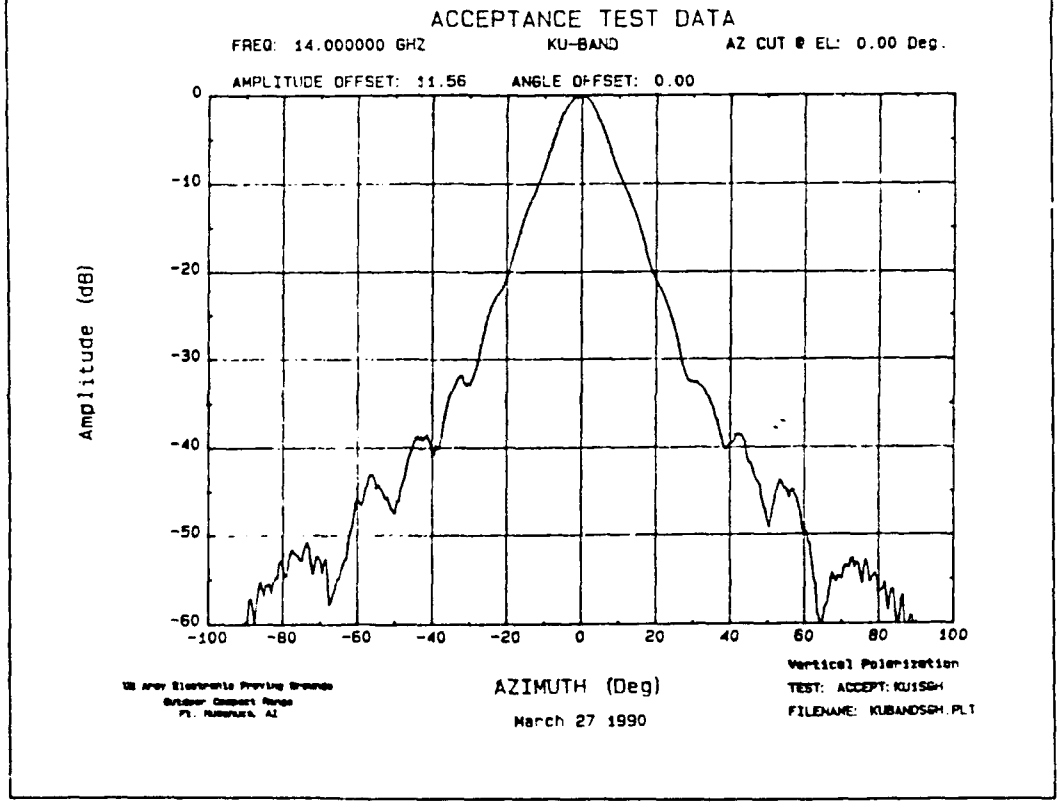

ACCEPTANCE TEST DATA
FREQ: 11.000000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 11.80
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X38SH
FILENAME: XBANDSSH.PLT

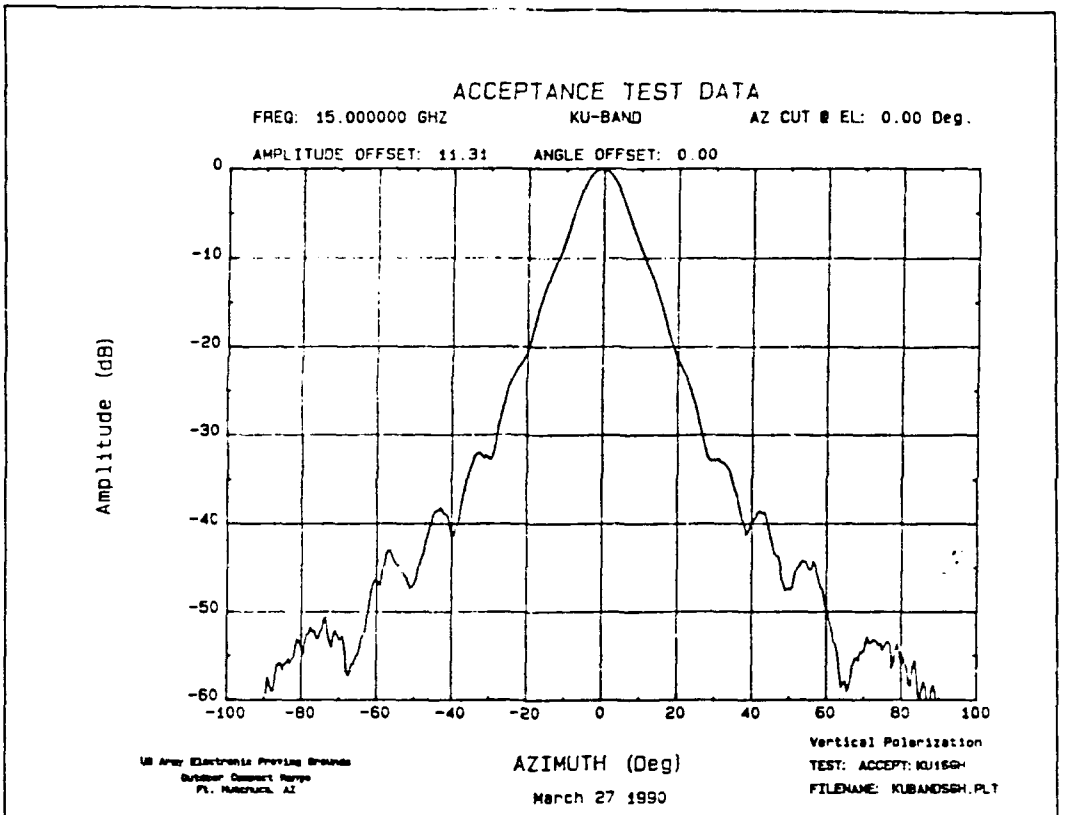

ACCEPTANCE TEST DATA
FREQ: 11.500000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 12.77
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X3SSH
FILENAME: XBANDSSH.PLT

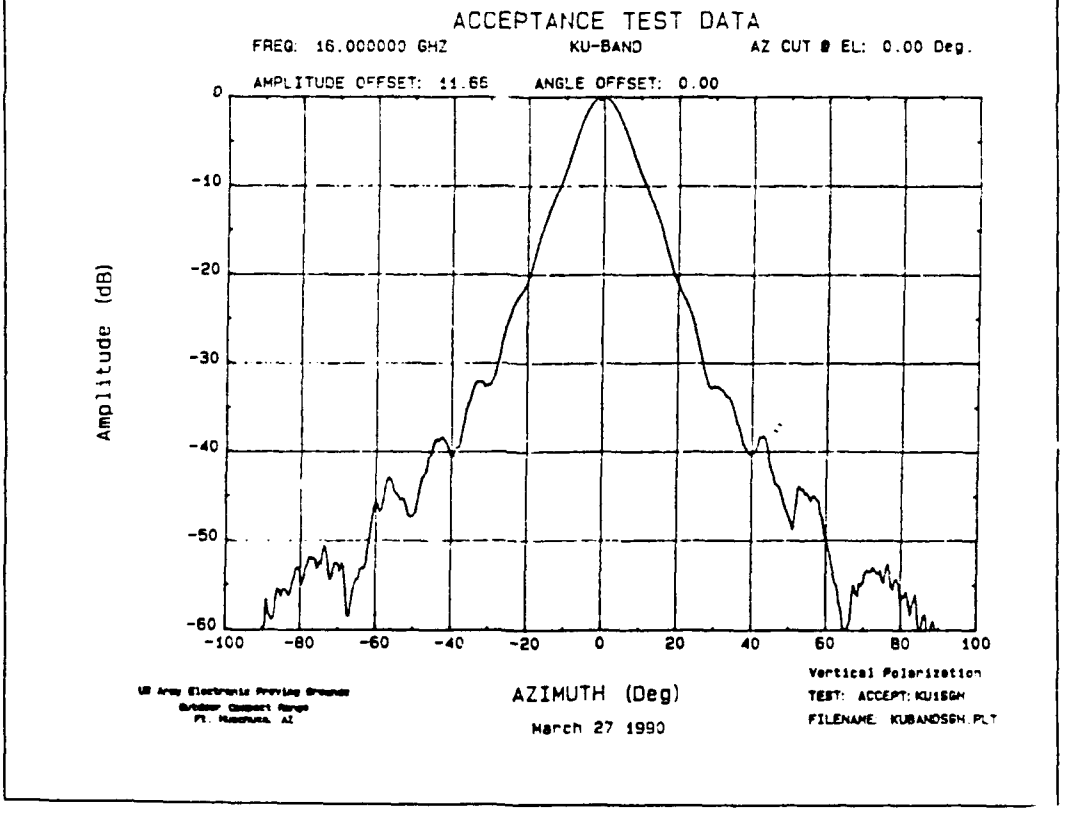

ACCEPTANCE TEST DATA
FREQ: 11.500000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 12.20
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X4SSH
FILENAME: XBANDSSH.PLT

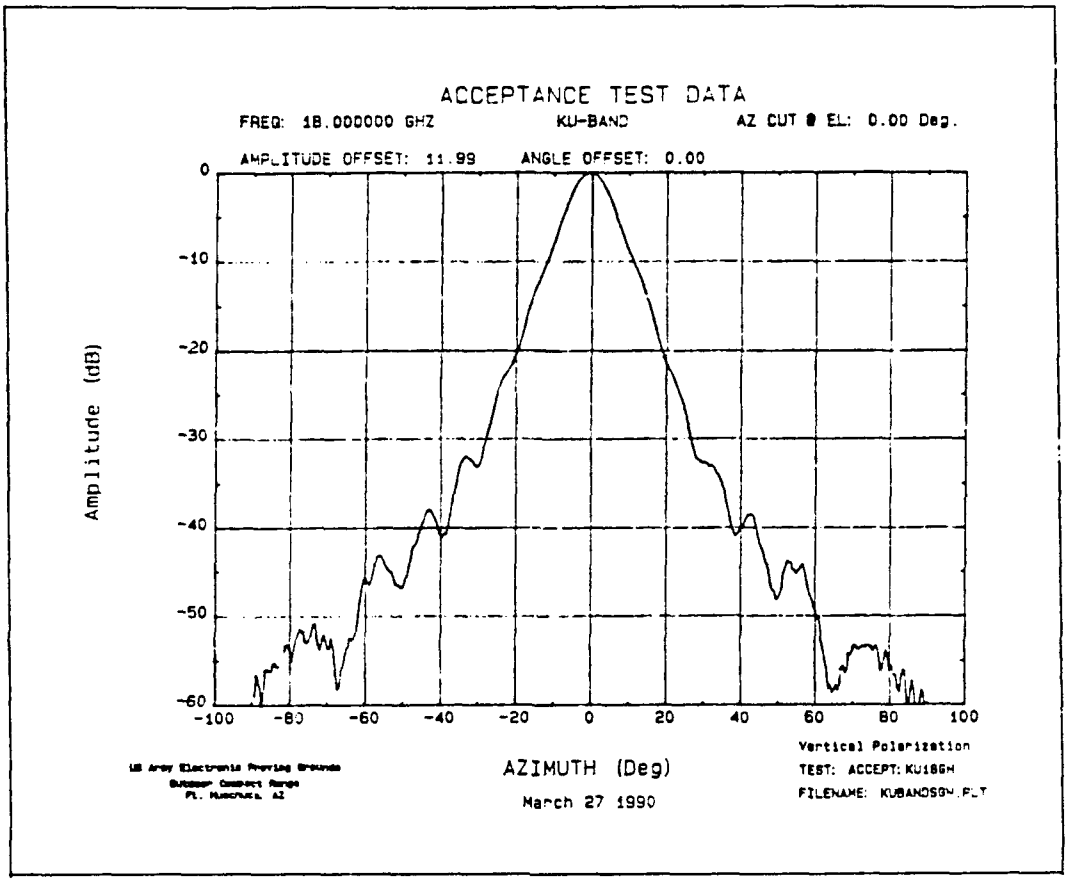

ACCEPTANCE TEST DATA
FREQ: 11.999900 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 12.62
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X45GH
FILENAME: XBANDSGH.PLT
ACCEPTANCE TEST DATA
FREQ: 12.400000 GHZ
X-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 14.30
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 24 1990
Vertical Polarization
TEST: ACCEPT: X45GH
FILENAME: XBANDSGH.PLT

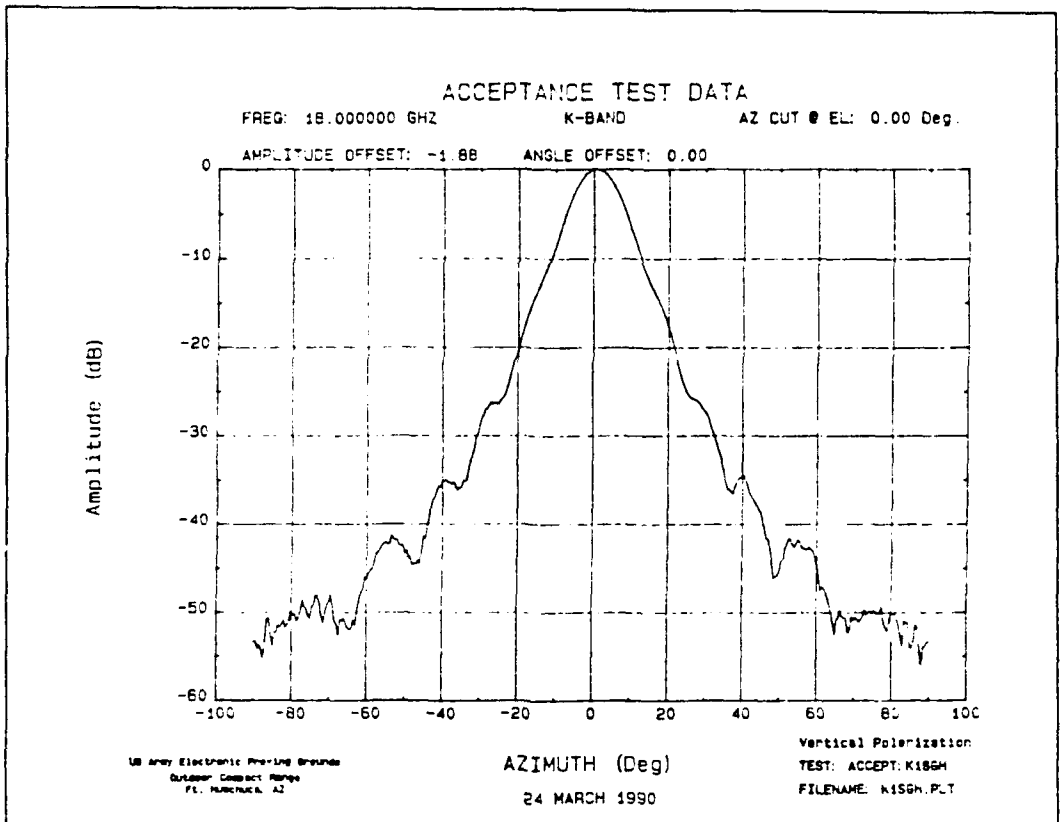

ACCEPTANCE TEST DATA
FREQ: 12.400000 GHZ
KU-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 11.93
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 27 1990
Vertical Polarization
TEST: ACCEPT:KU1SGH
FILENAME: KUBANDSGH.PLT

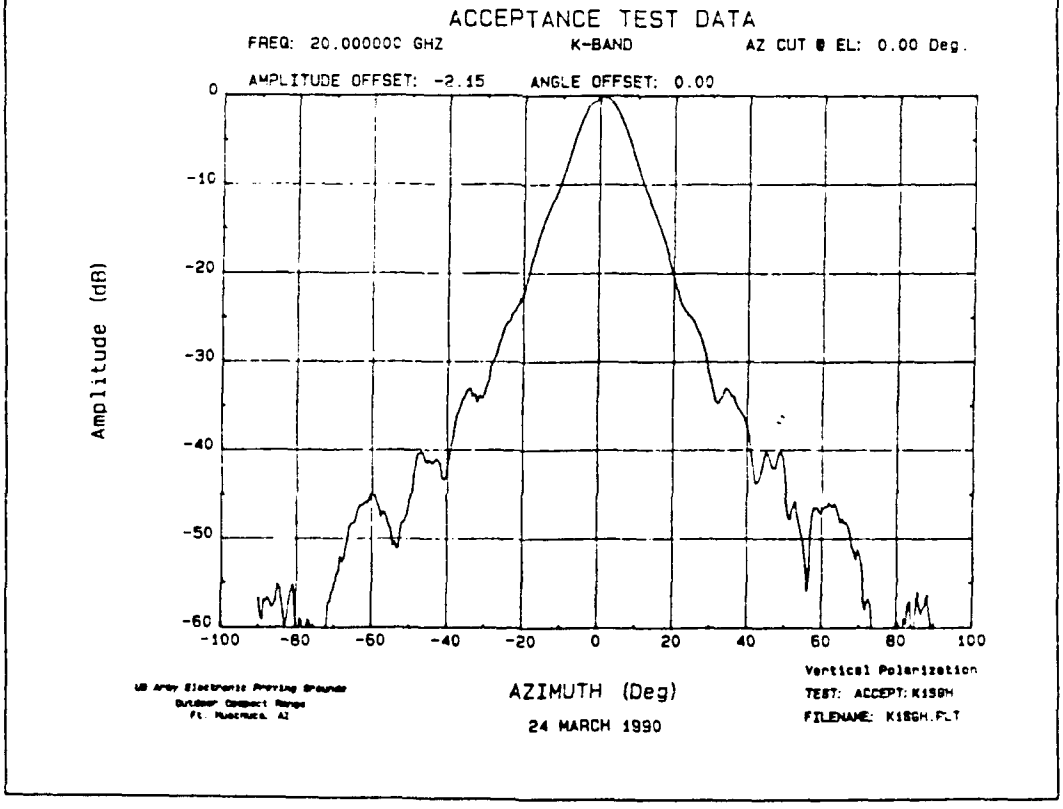

ACCEPTANCE TEST DATA
FREQ: 14.000000 GHZ
KU-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 11.56
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 27 1990
Vertical Polarization
TEST: ACCEPT:KU1SGH
FILENAME: KUBANDSGH.PLT

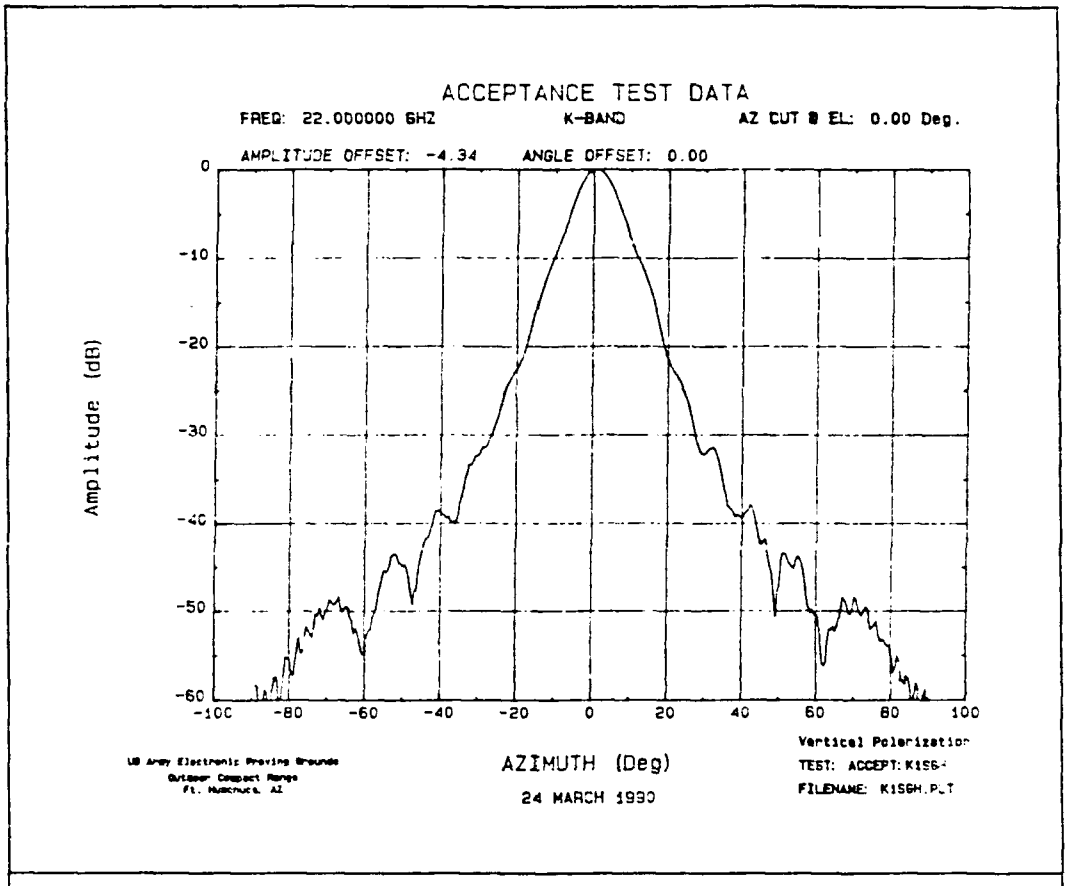

ACCEPTANCE TEST DATA
FREQ: 15.000000 GHZ
KU-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 11.31
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 27 1990
Vertical Polarization
TEST: ACCEPT:KU15GH
FILENAME: KUBANDSGH.PLT

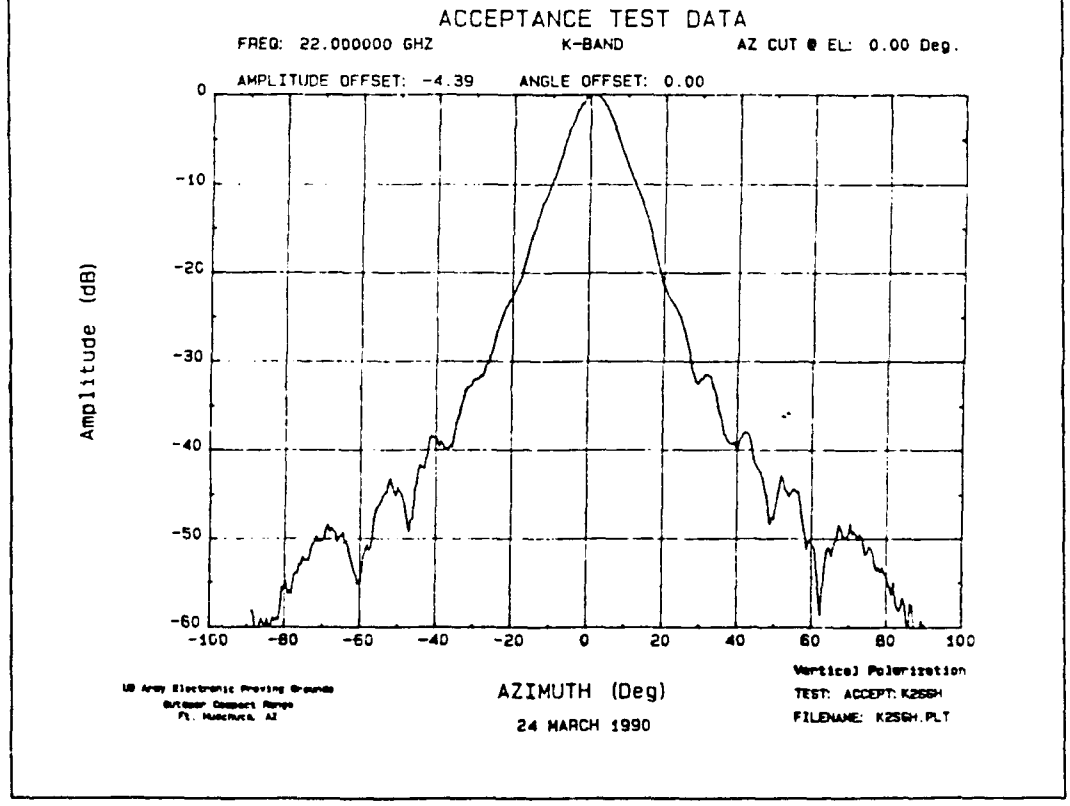

ACCEPTANCE TEST DATA
FREQ: 16.000000 GHZ
KU-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 11.66
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 27 1990
Vertical Polarization
TEST: ACCEPT:KU15GH
FILENAME: KUBANDSGH.PLT

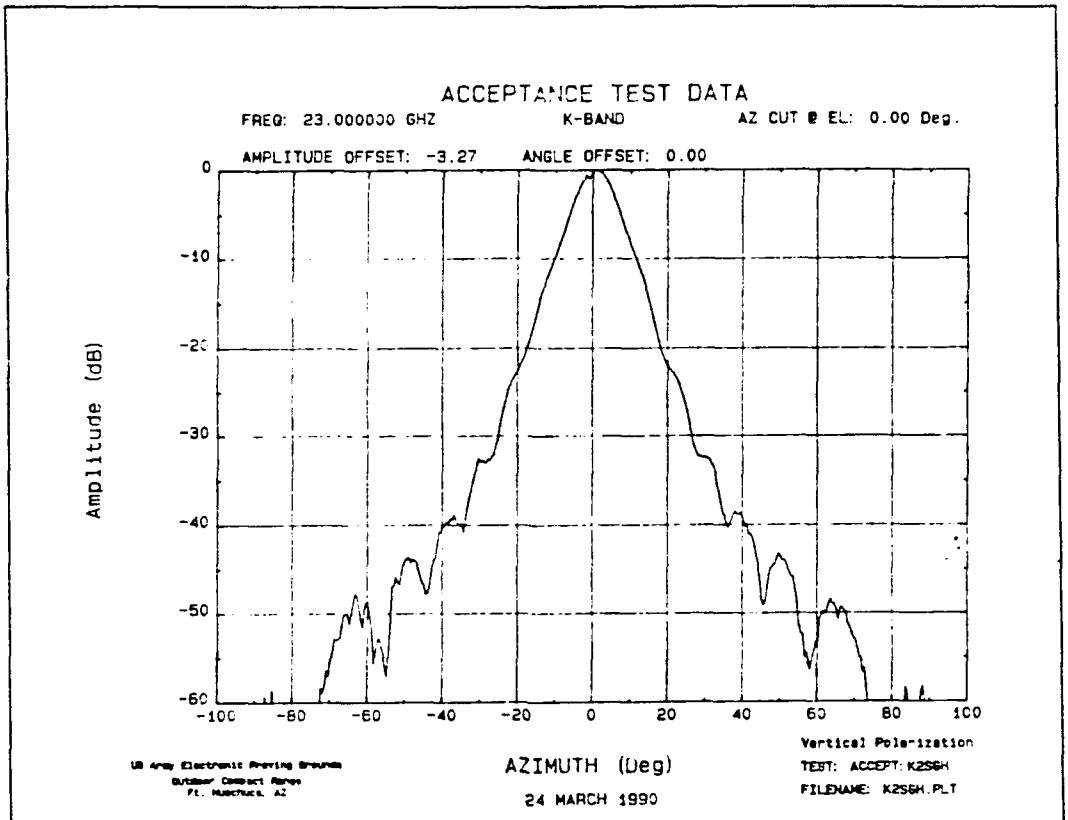

ACCEPTANCE TEST DATA
FREQ: 18.000000 GHZ
KU-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 11.99
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 27 1990
Vertical Polarization
TEST: ACCEPT: KU18GH
FILENAME: KUBANDSGN.PLT

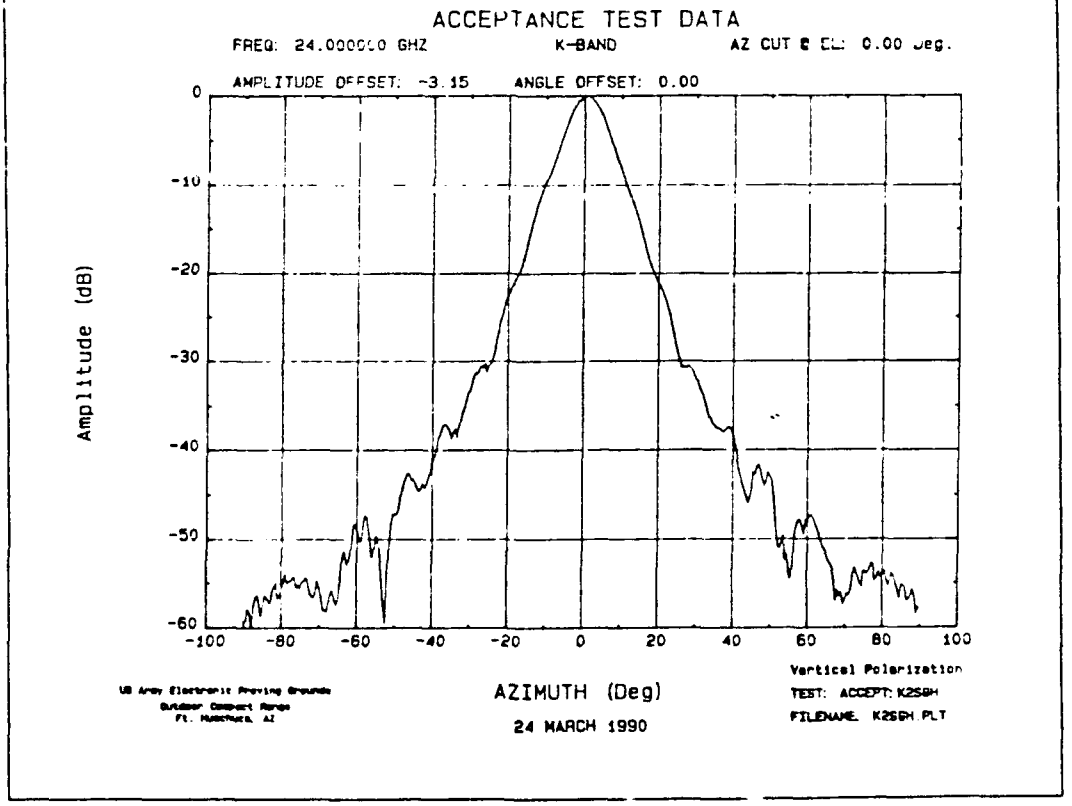

ACCEPTANCE TEST DATA
FREQ: 18.000000 GHZ
K-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: -1.88
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT:K18GH
FILENAME: K18GH.PLT

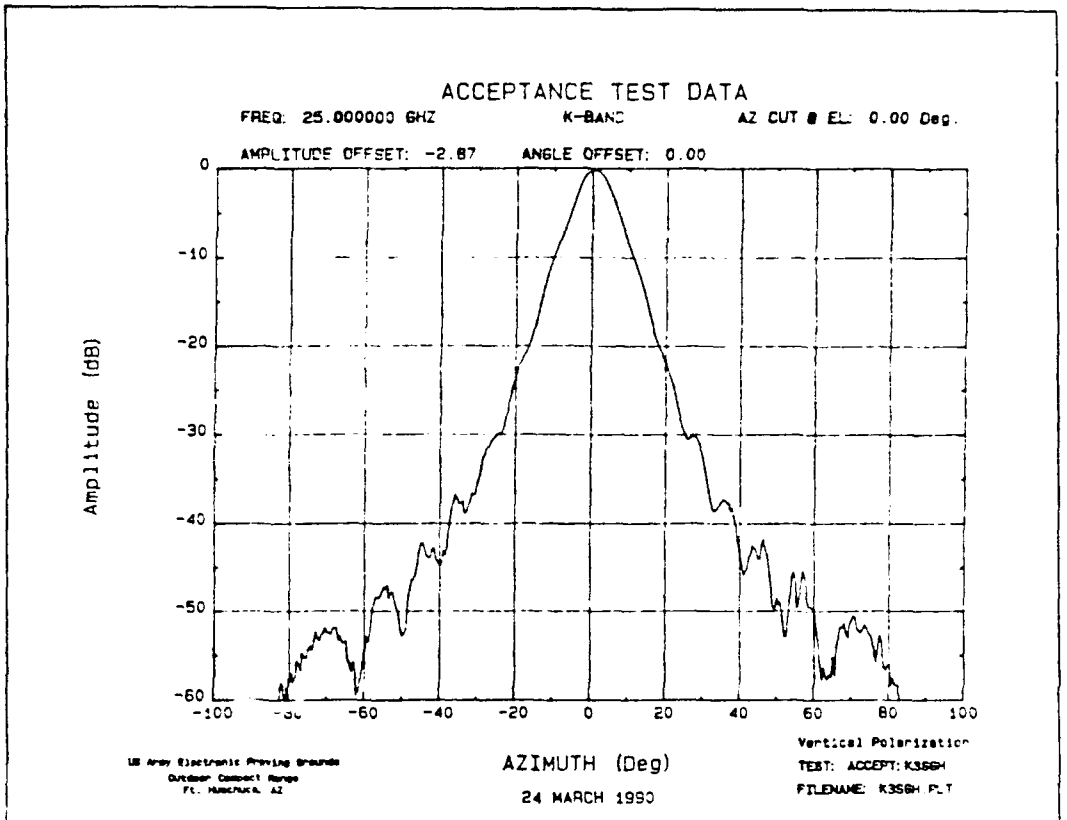

ACCEPTANCE TEST DATA
FREQ: 20.000000 GHZ
K-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: -2.15
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT:K19GH
FILENAME: K19GH.PLT

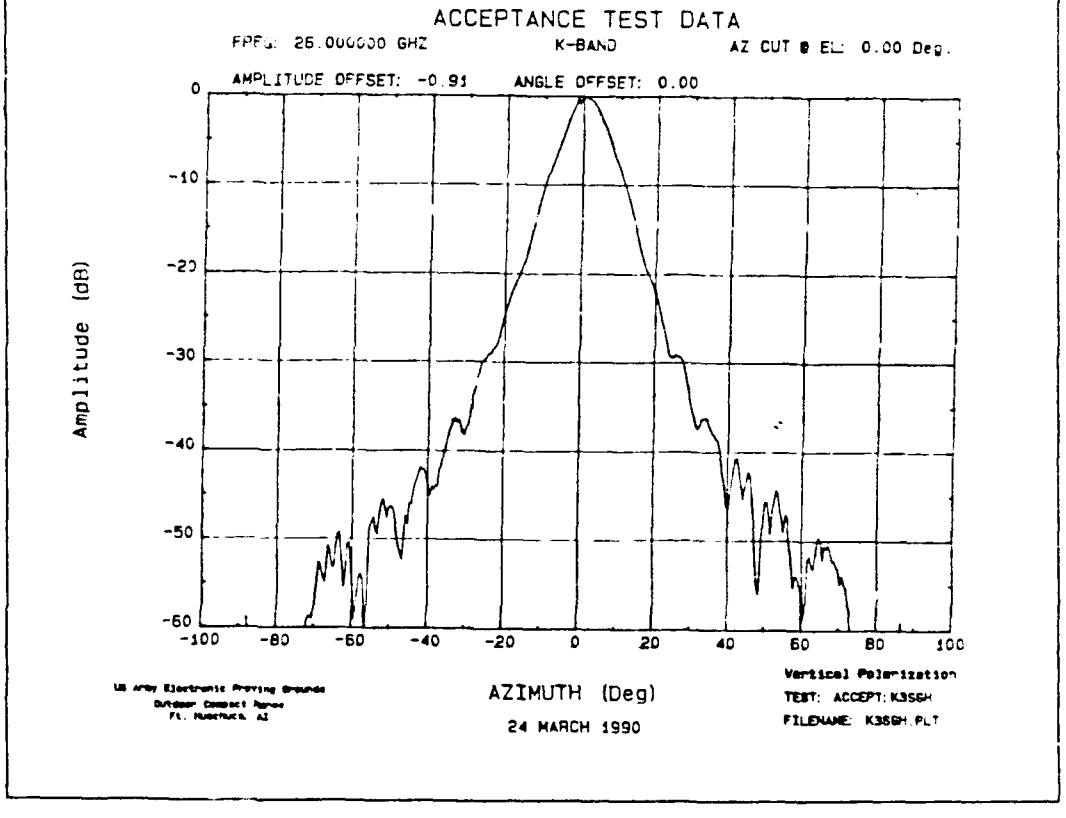

ACCEPTANCE TEST DATA
FREQ: 22.000000 GHZ
K-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: -4.34
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: K1SG
FILENAME: K1SGH.PLT

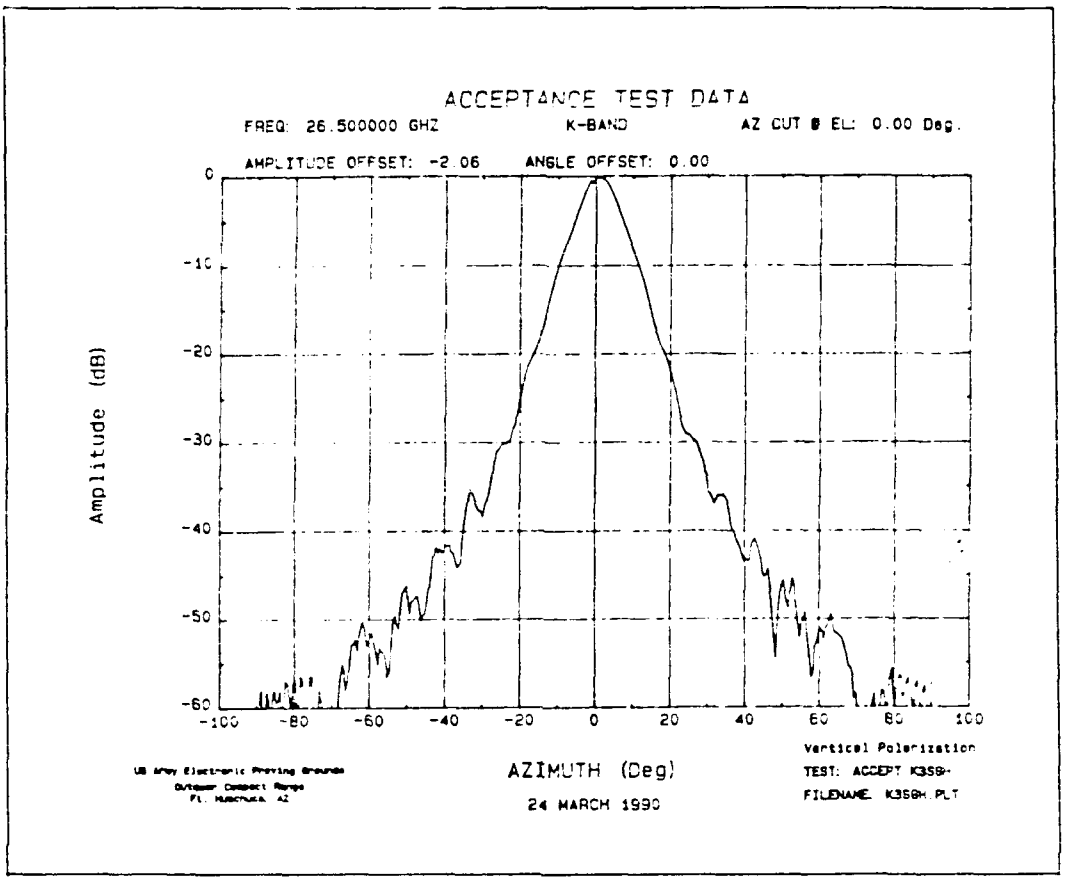

ACCEPTANCE TEST DATA
FREQ: 22.000000 GHZ
K-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: -4.39
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: K2SGH
FILENAME: K2SGH.PLT

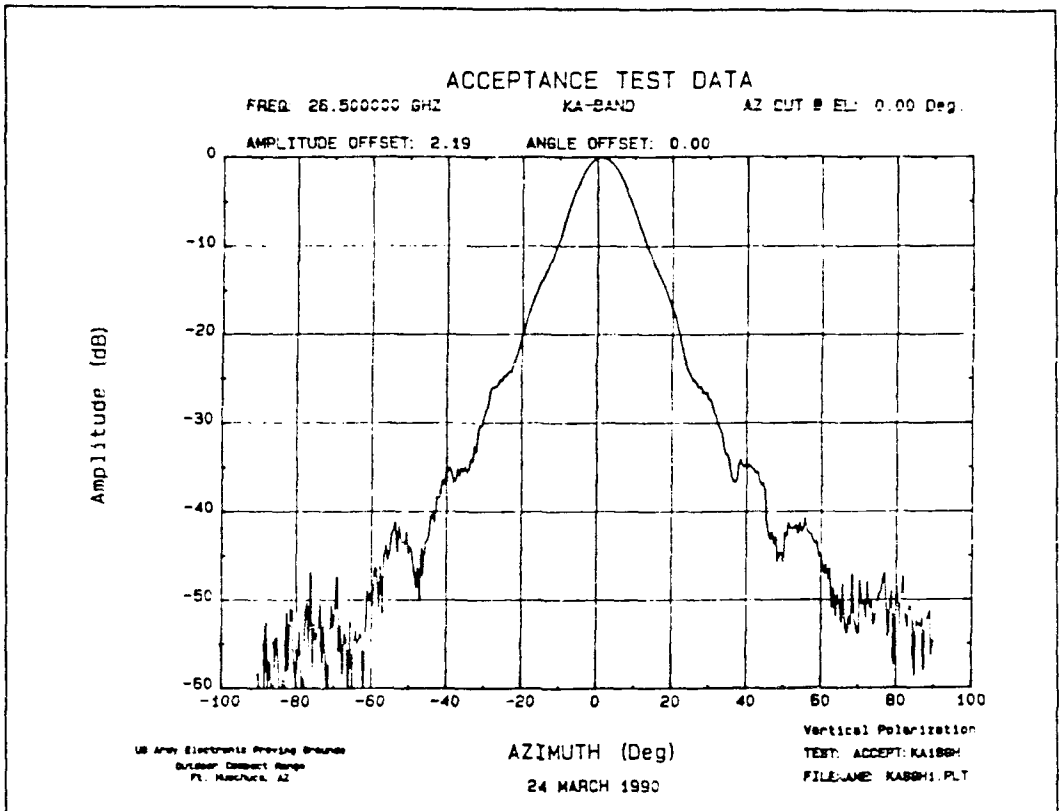

ACCEPTANCE TEST DATA
FREQ: 23.000000 GHZ
K-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: -3.27
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: K2SGH
FILENAME: K2SGH.PLT

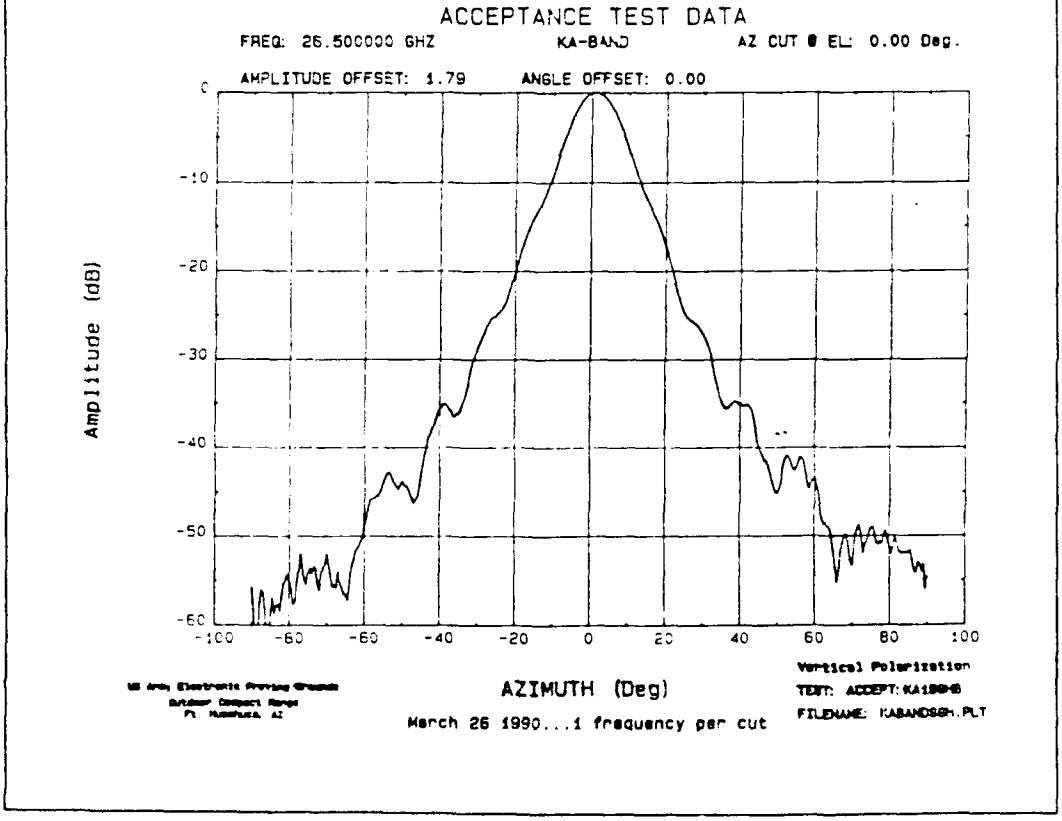

ACCEPTANCE TEST DATA
FREQ: 24.000000 GHZ
K-BAND
AMPLITUDE OFFSET: -3.15
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: K2SGH
FILENAME: K2SGH.PLT

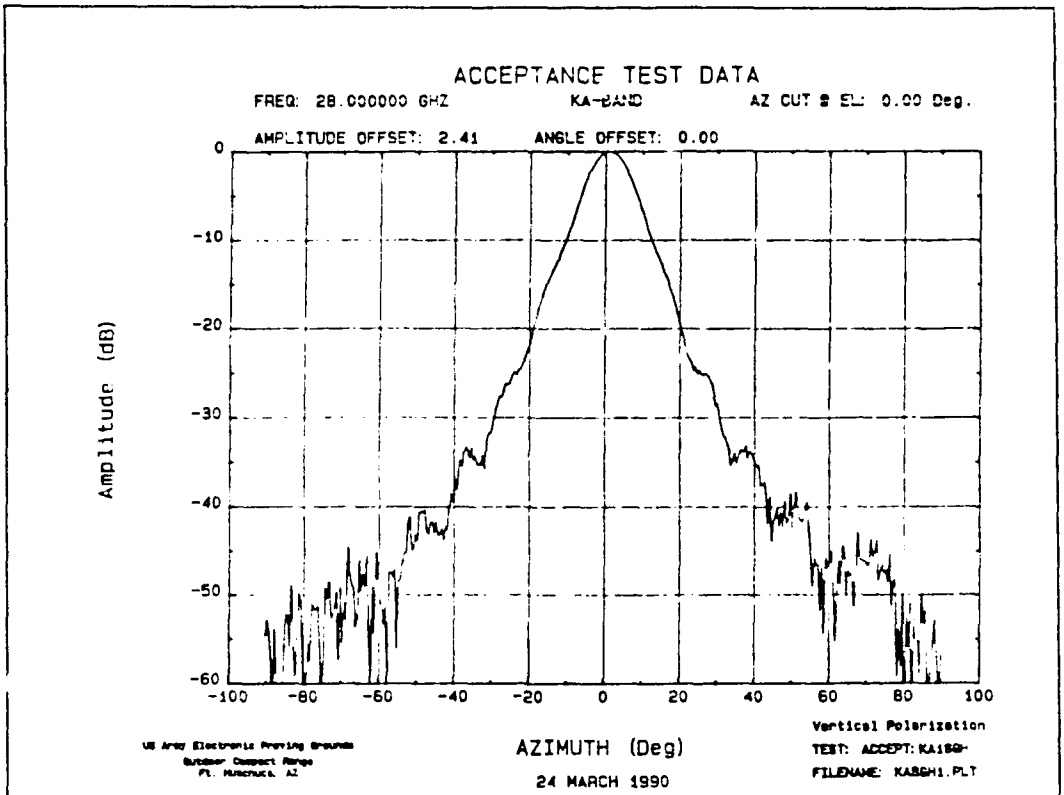

ACCEPTANCE TEST DATA
FREQ: 25.000000 GHZ
K-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: -2.87
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: K35GH
FILENAME: K35GH.PLT

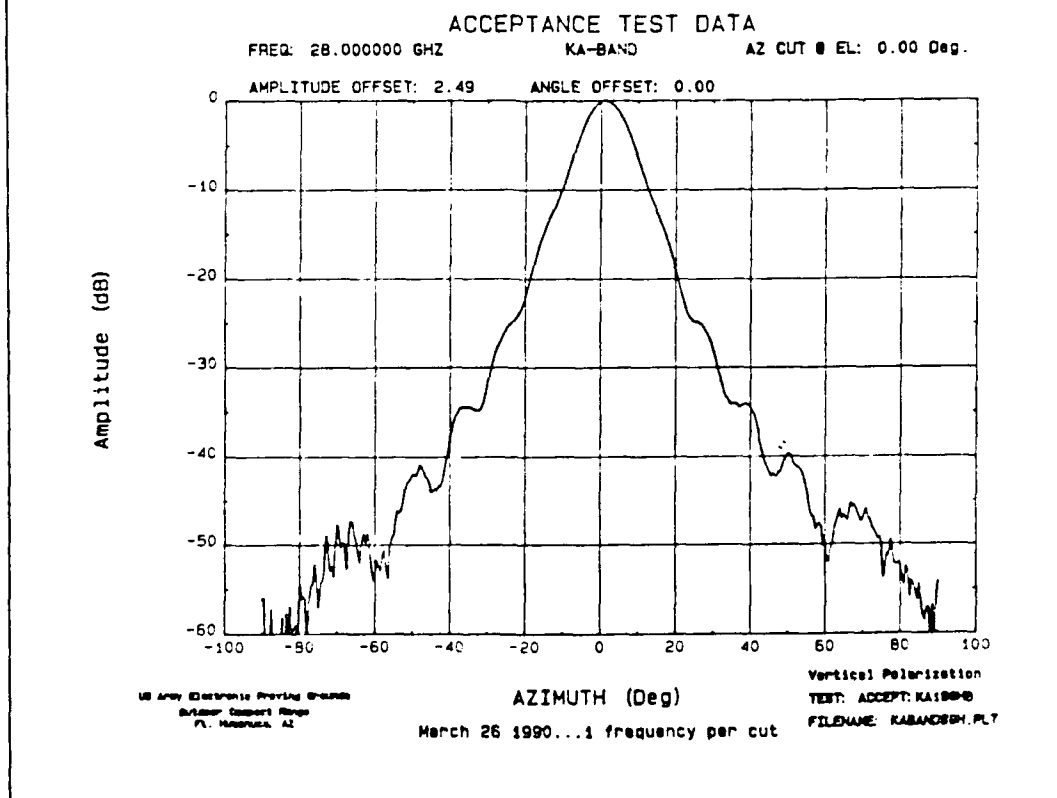

ACCEPTANCE TEST DATA
FREQ: 26.000000 GHZ
K-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: -0.91
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: K35GH
FILENAME: K35GH.PLT

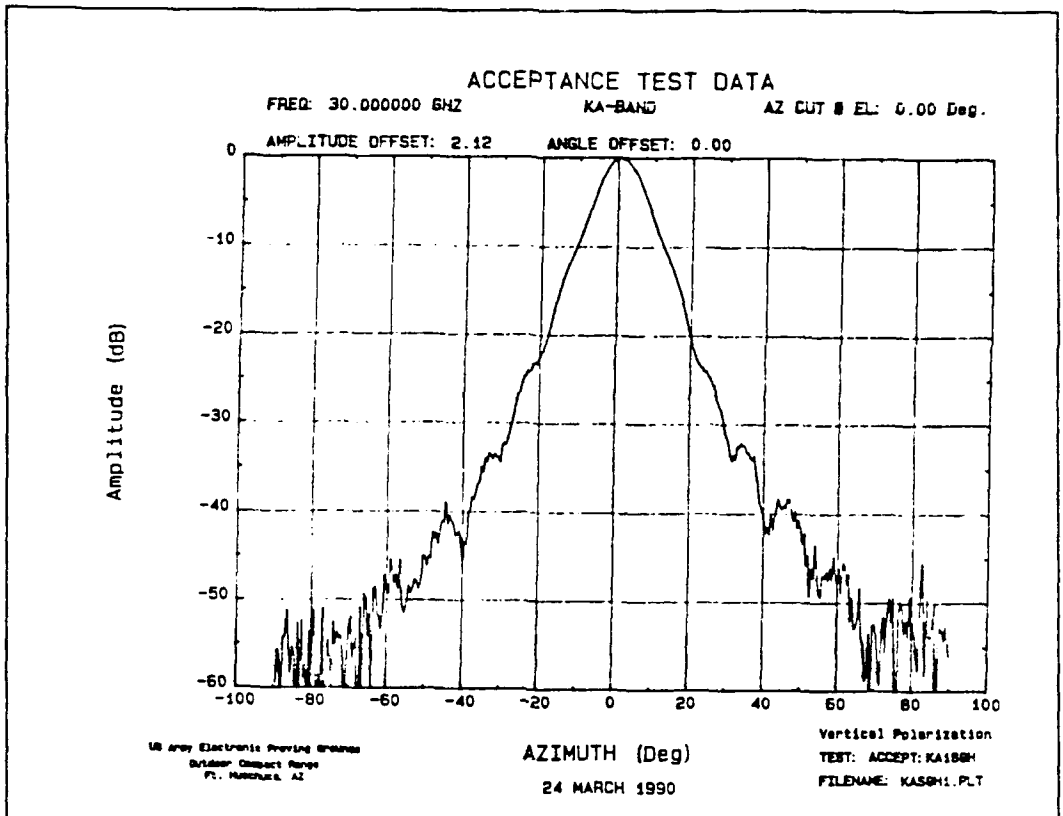

ACCEPTANCE TEST DATA
FREQ: 26.500000 GHZ
K-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: -2.06
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT K35GH
FILENAME: K35GH.PLT

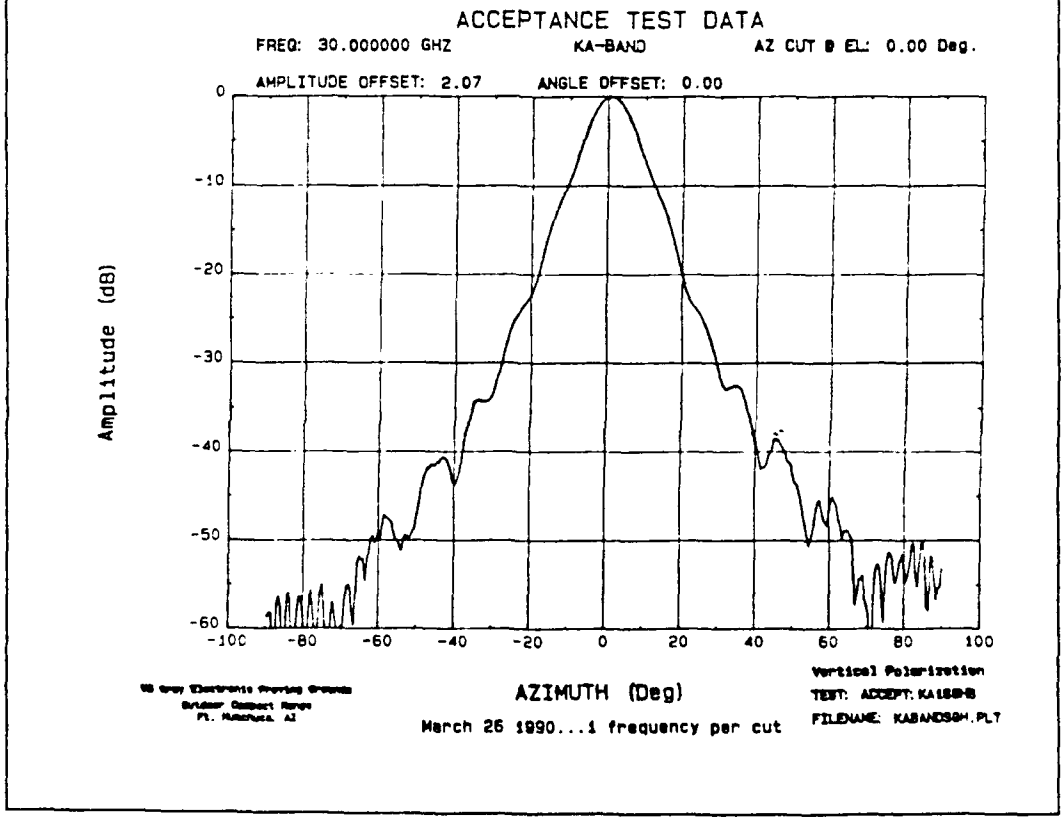

ACCEPTANCE TEST DATA
FREQ: 26.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 2.19
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA1SGH
FILENAME: KASGH1.PLT

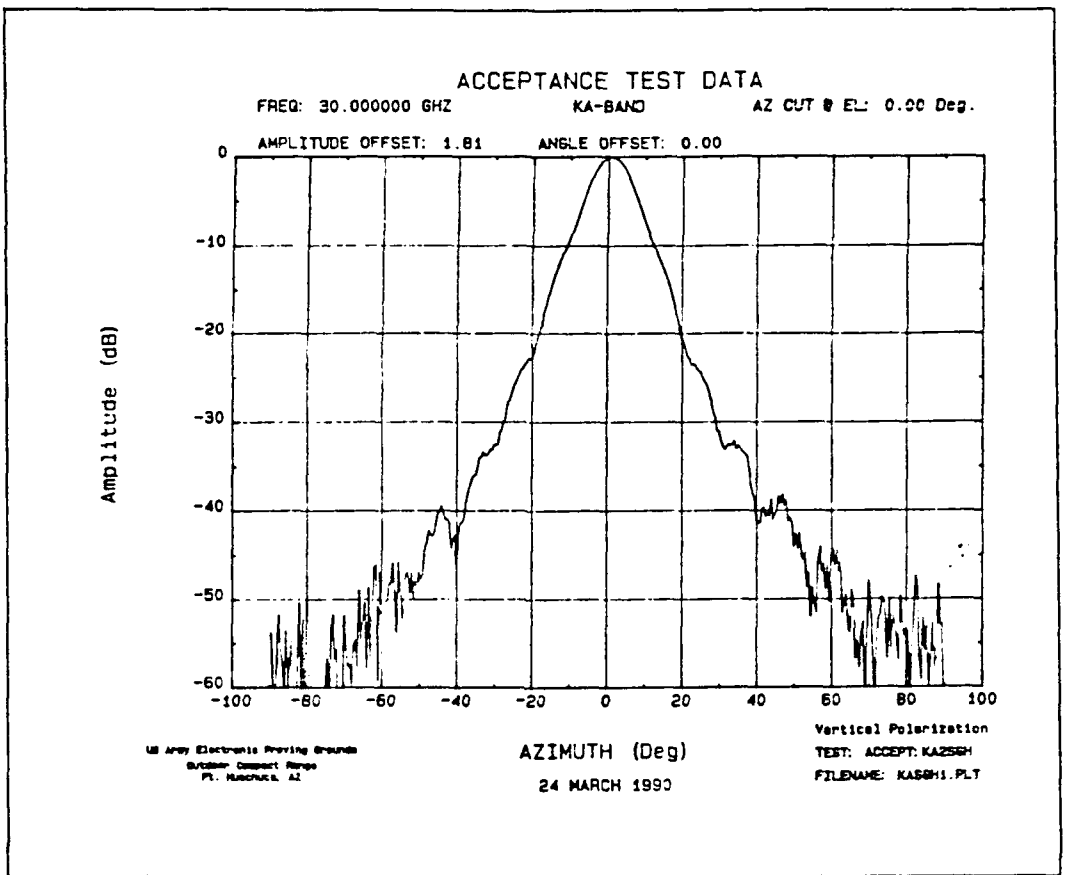

ACCEPTANCE TEST DATA
FREQ: 26.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 1.79
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KA1SGHS
FILENAME: KABANDSGH.PLT

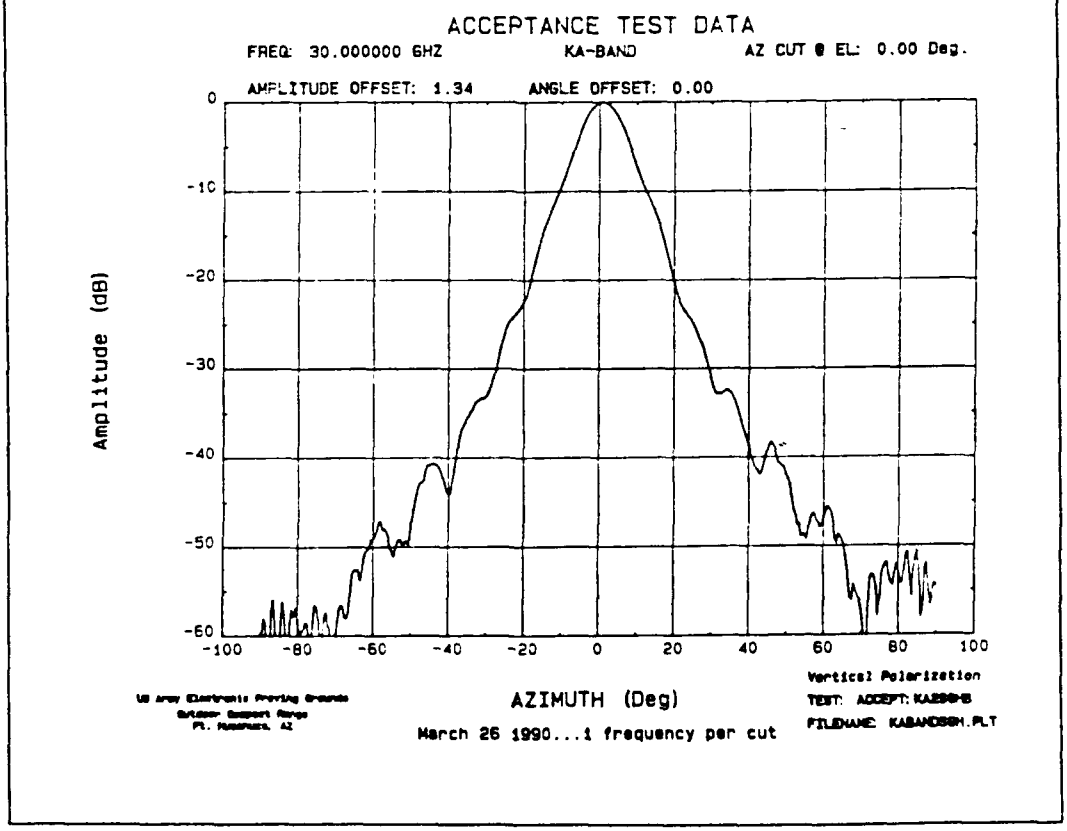

ACCEPTANCE TEST DATA
FREQ: 28.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 2.41
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA1SGH
FILENAME: KASGH1.PLT

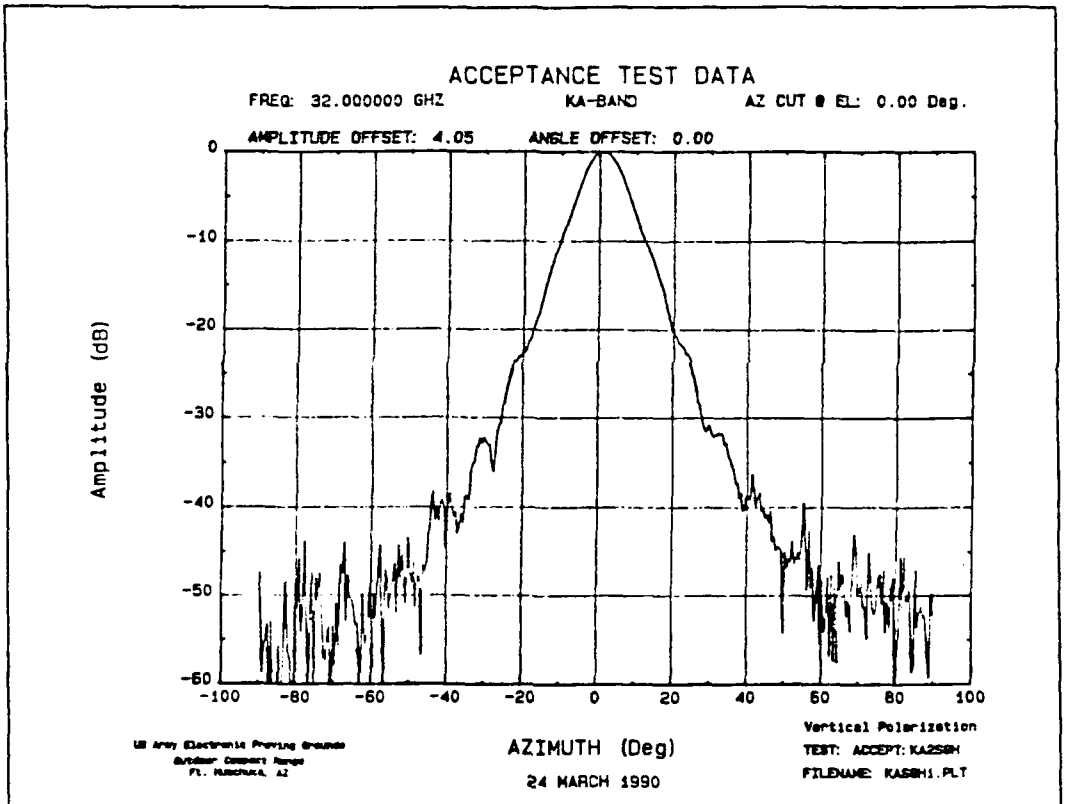

ACCEPTANCE TEST DATA
FREQ: 28.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 2.49
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KA1SGHB
FILENAME: KABANDSGH.PLT

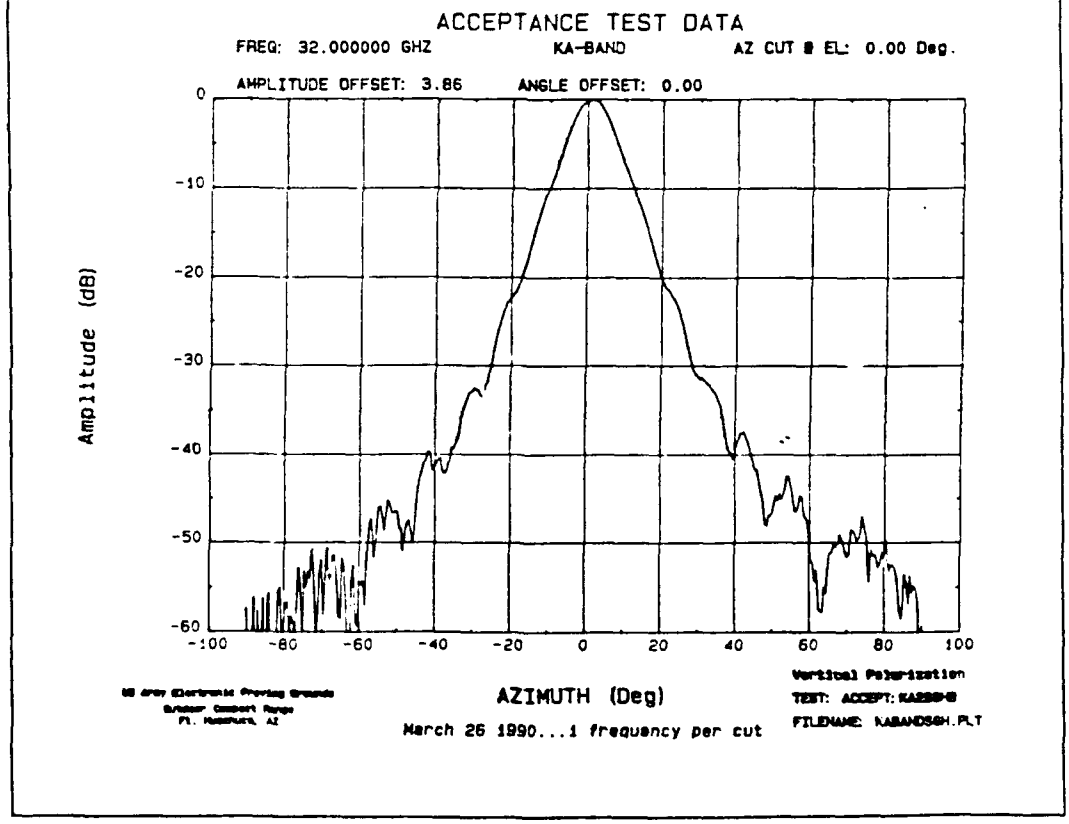

ACCEPTANCE TEST DATA
FREQ: 30.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 2.12
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA1SGH
FILENAME: KASGH1.PLT

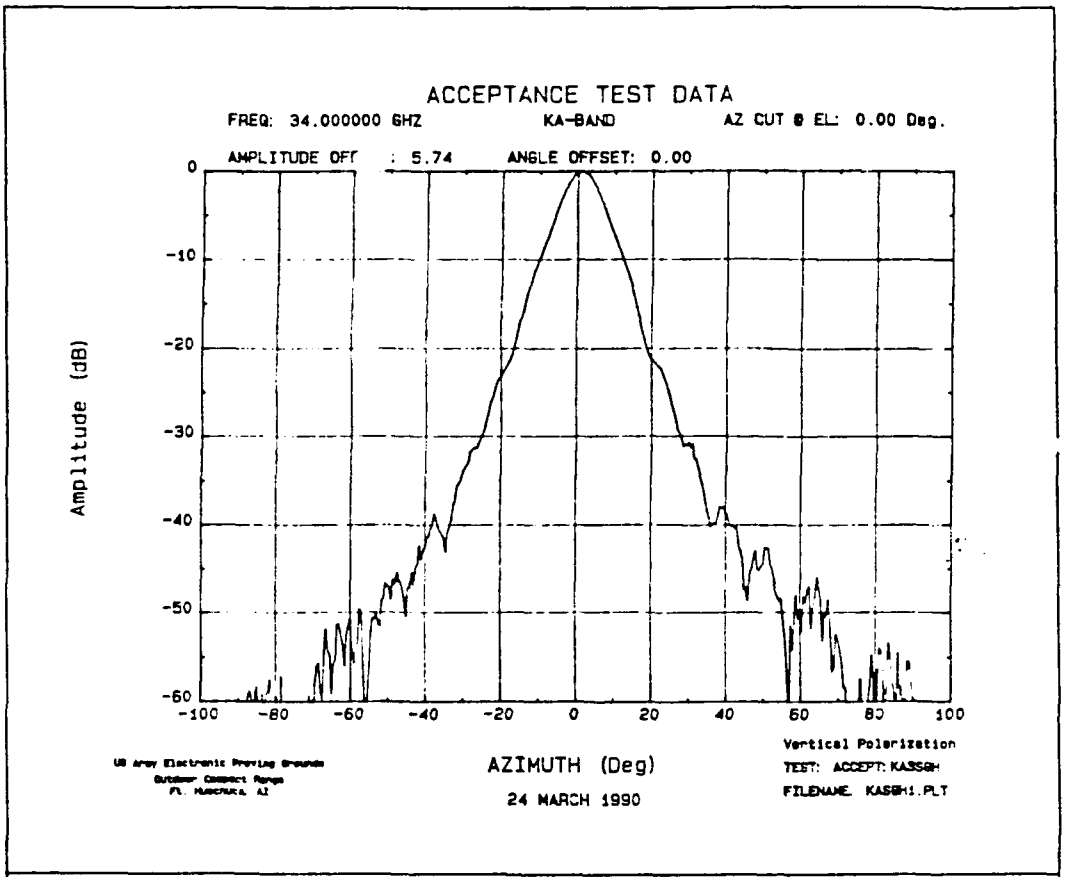

ACCEPTANCE TEST DATA
FREQ: 30.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 2.07
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KA1SGHB
FILENAME: KABANDSGH.PLT

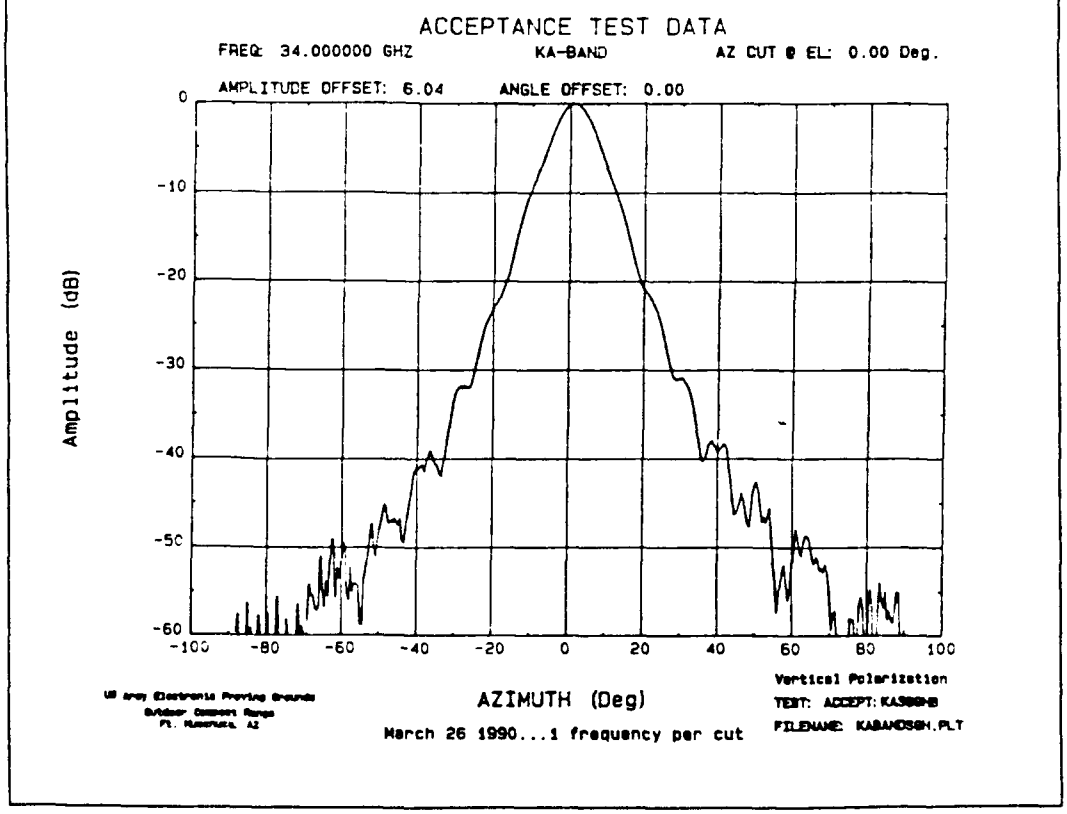

ACCEPTANCE TEST DATA
FREQ: 30.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 1.81
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT:KA25GH
FILENAME: KA5GH1.PLT

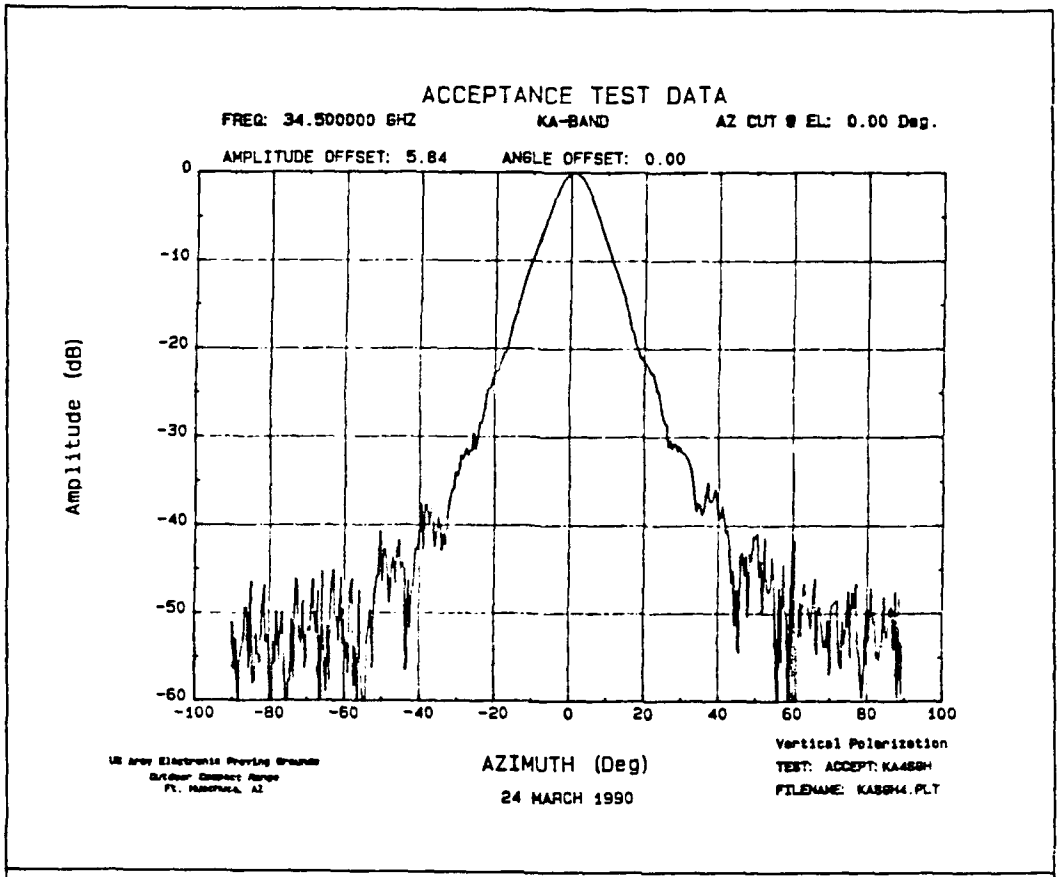

ACCEPTANCE TEST DATA
FREQ: 30.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 1.34
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization

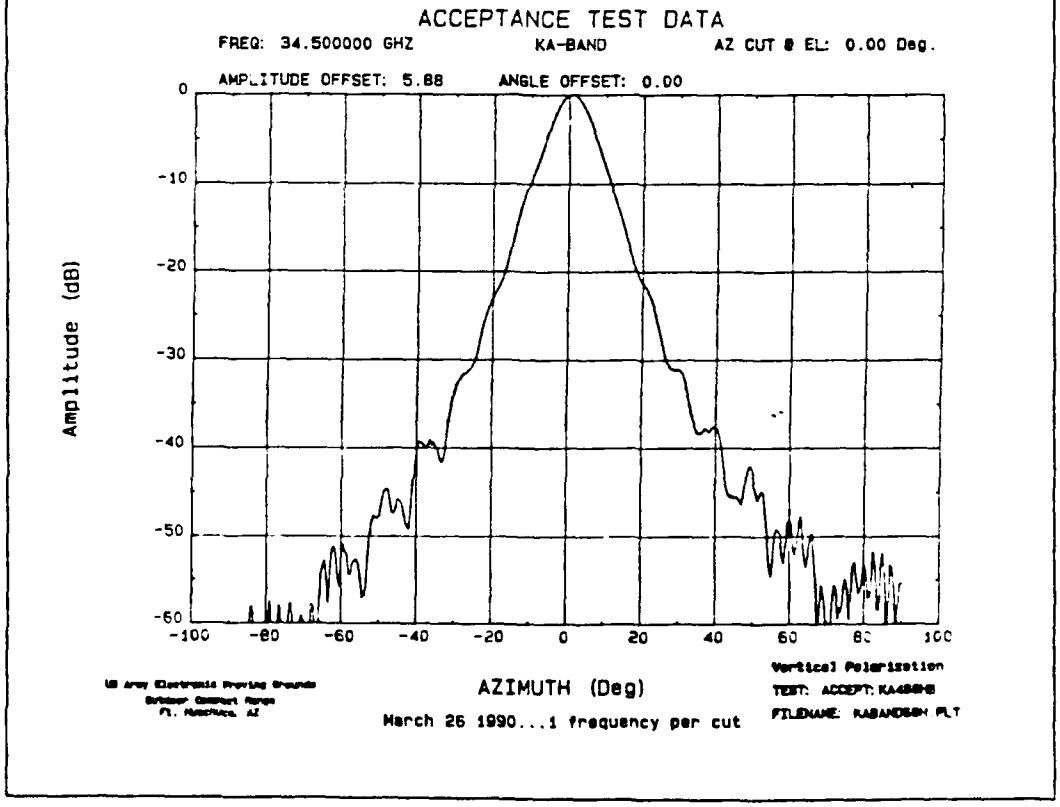

ACCEPTANCE TEST DATA
FREQ: 32.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.05
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA2SBH
FILENAME: KASBH1.PLT

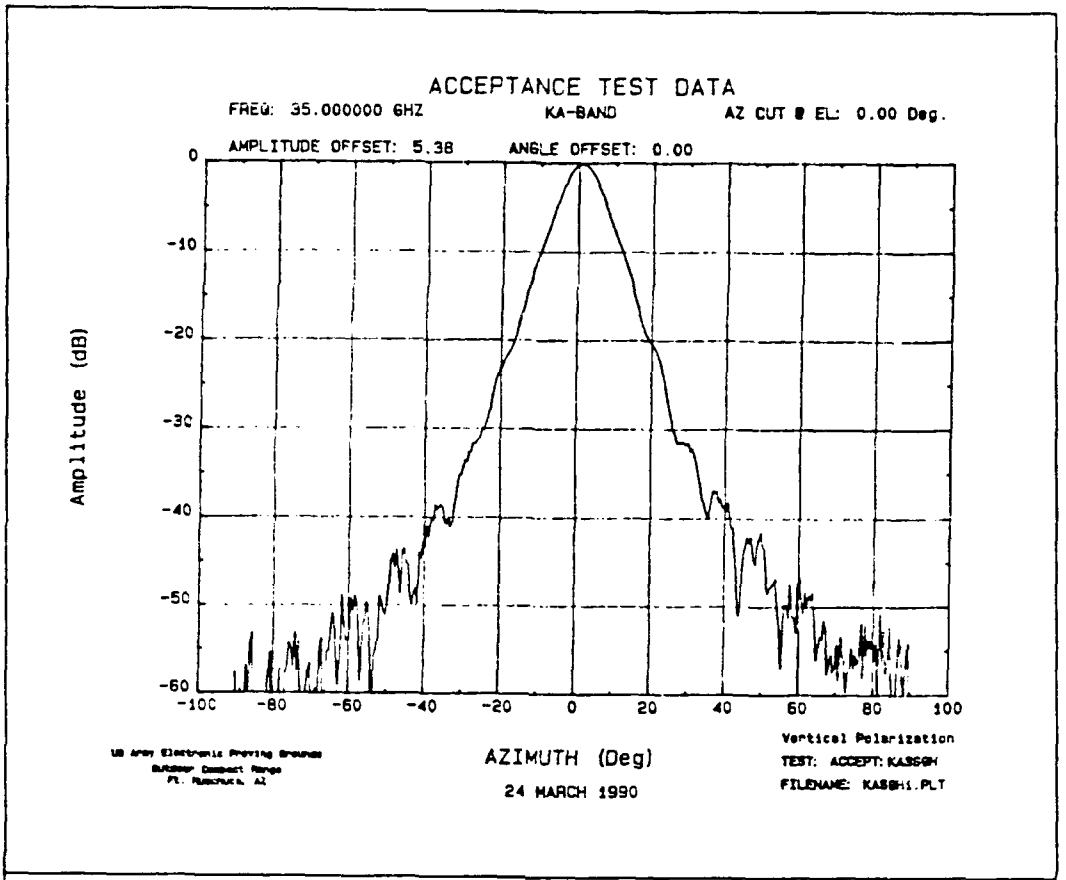

ACCEPTANCE TEST DATA
FREQ: 32.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 3.86
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KA2SBHB
FILENAME: KABANDSBH.PLT

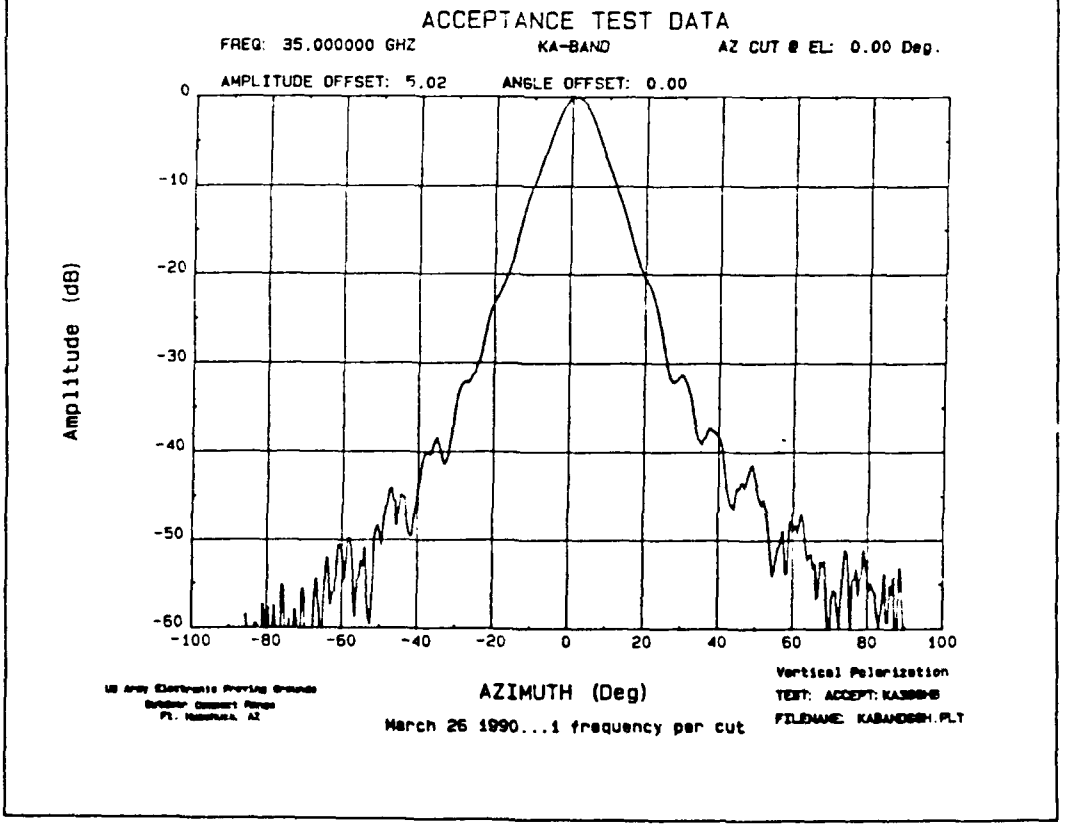

ACCEPTANCE TEST DATA
FREQ: 34.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFF : 5.74
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KASSBH
FILENAME: KASBH1.PLT

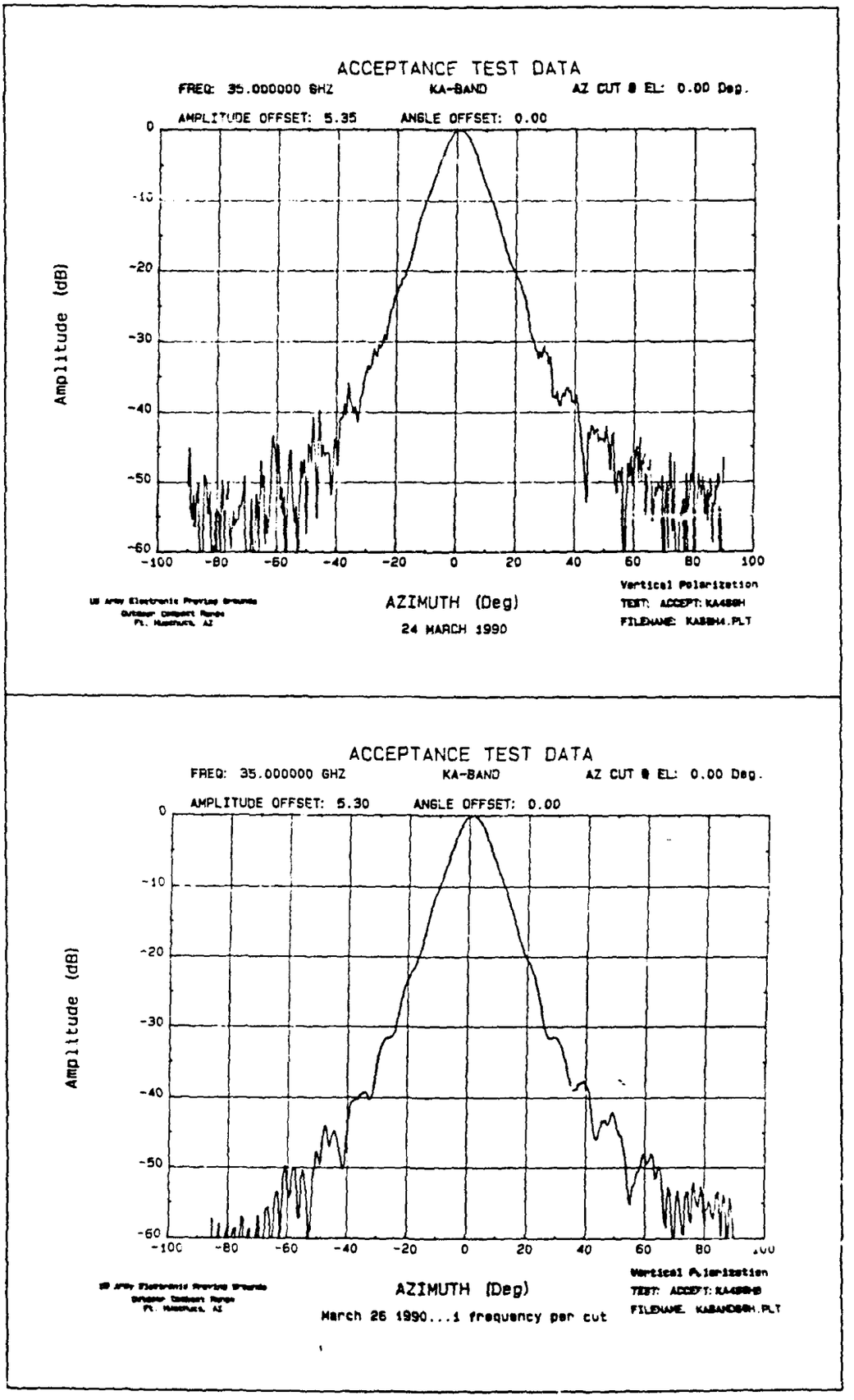

ACCEPTANCE TEST DATA
FREQ: 34.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 6.04
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
FILENAME: KABANDSBH.PLT

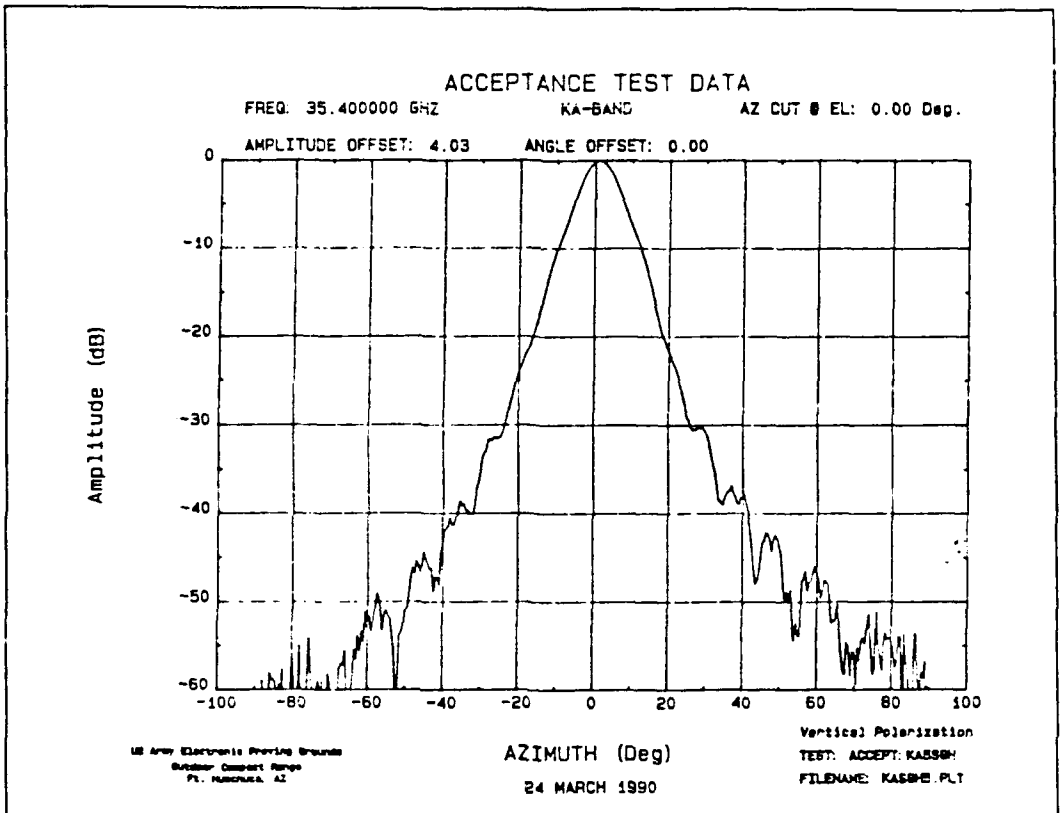

ACCEPTANCE TEST DATA
FREQ: 34.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.84
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA4SSH
FILENAME: KASSH4.PLT

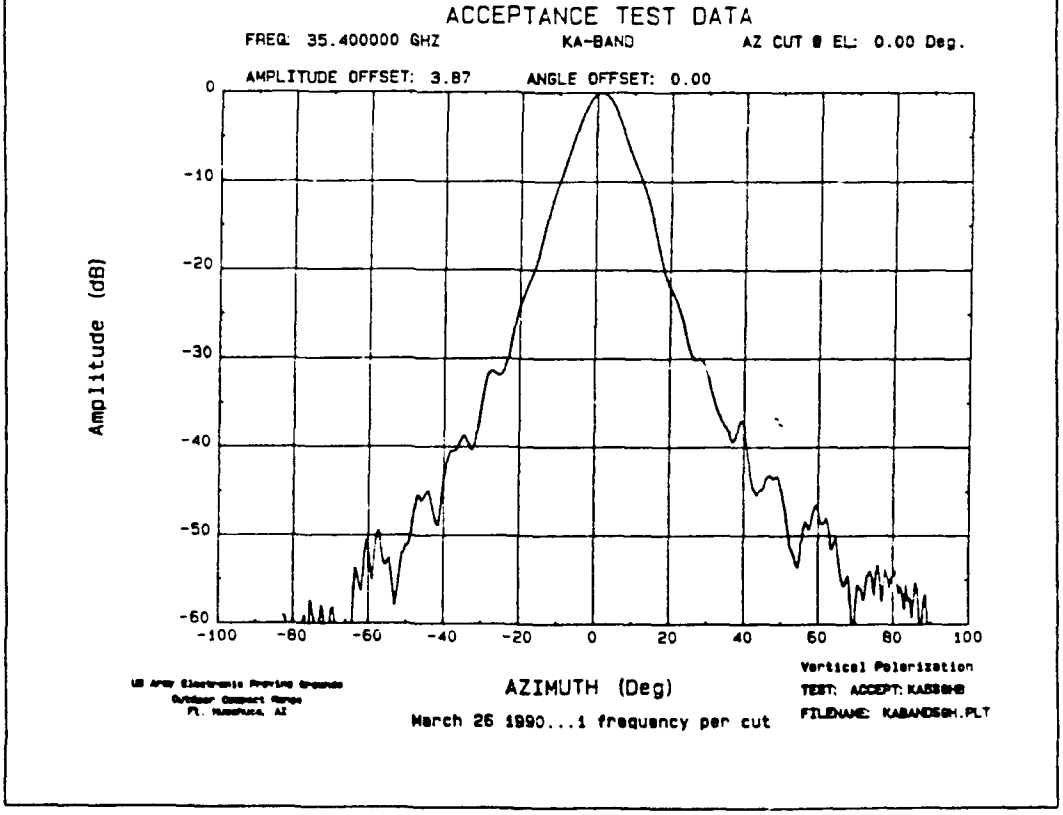

ACCEPTANCE TEST DATA
FREQ: 34.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.88
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization

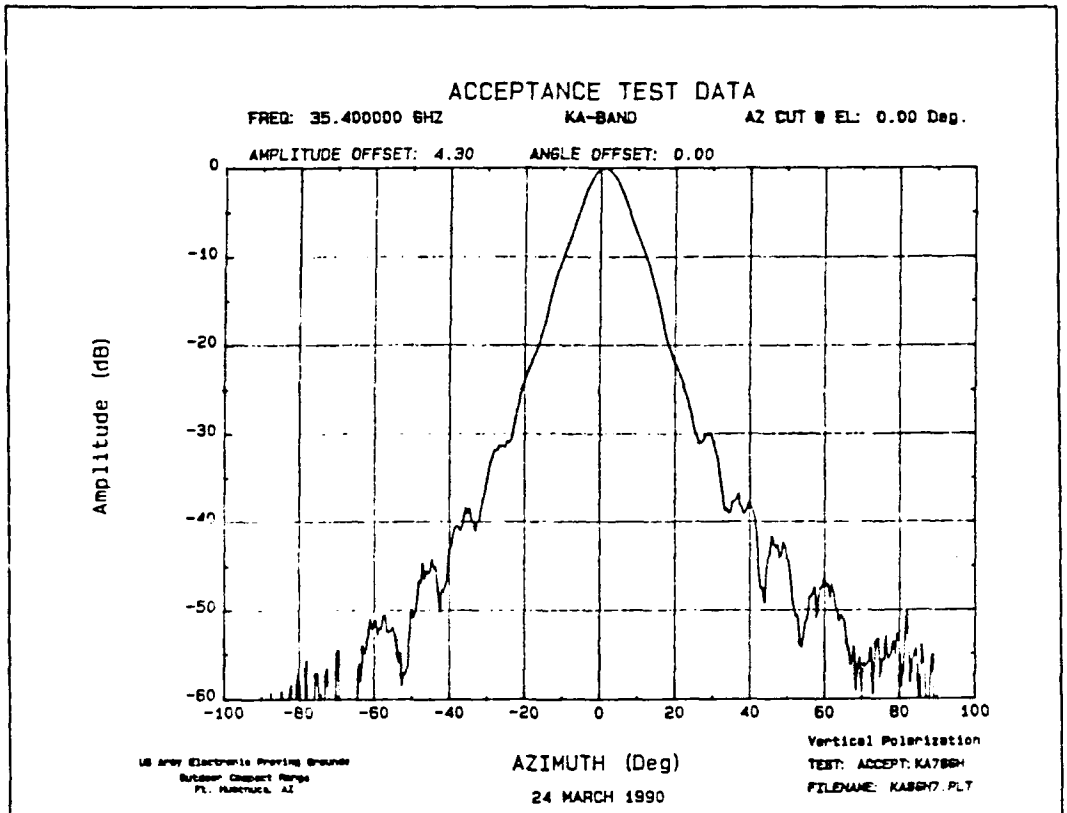

ACCEPTANCE TEST DATA
FREQ: 35.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.38
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KASSGH
FILENAME: KASSHi.PLT

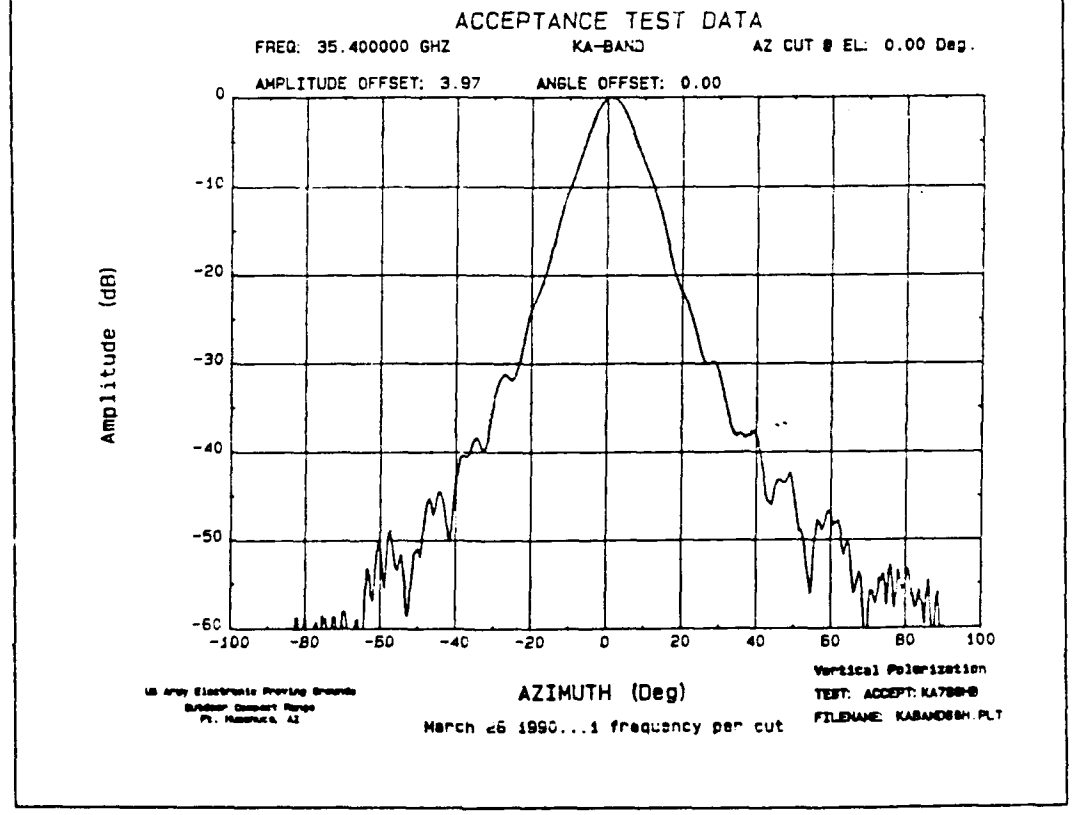

ACCEPTANCE TEST DATA
FREQ: 35.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.02
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KA
FILENAME: KABANDSSH.PLT

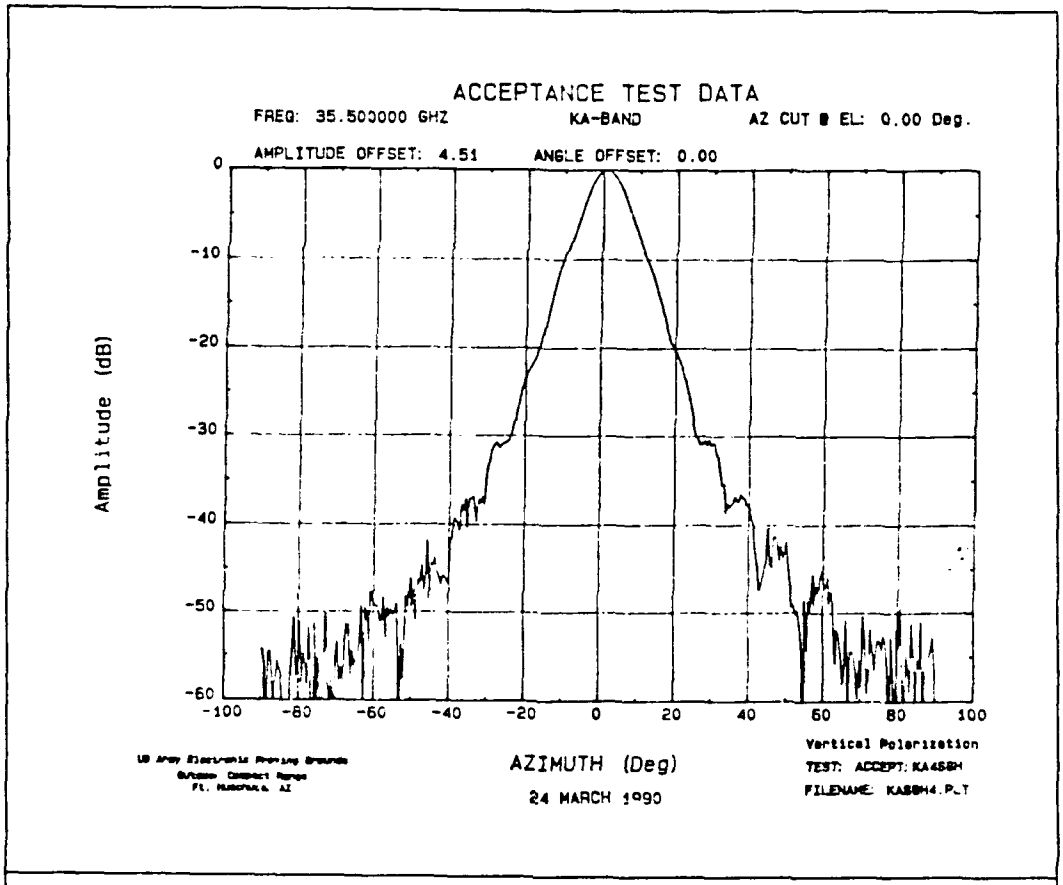

ACCEPTANCE TEST DATA
FREQ: 35.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.35
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA4BBH
FILENAME: KABBH4.PLT
ACCEPTANCE TEST DATA
FREQ: 35.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.30
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
FILENAME: KABANDBBH.PLT

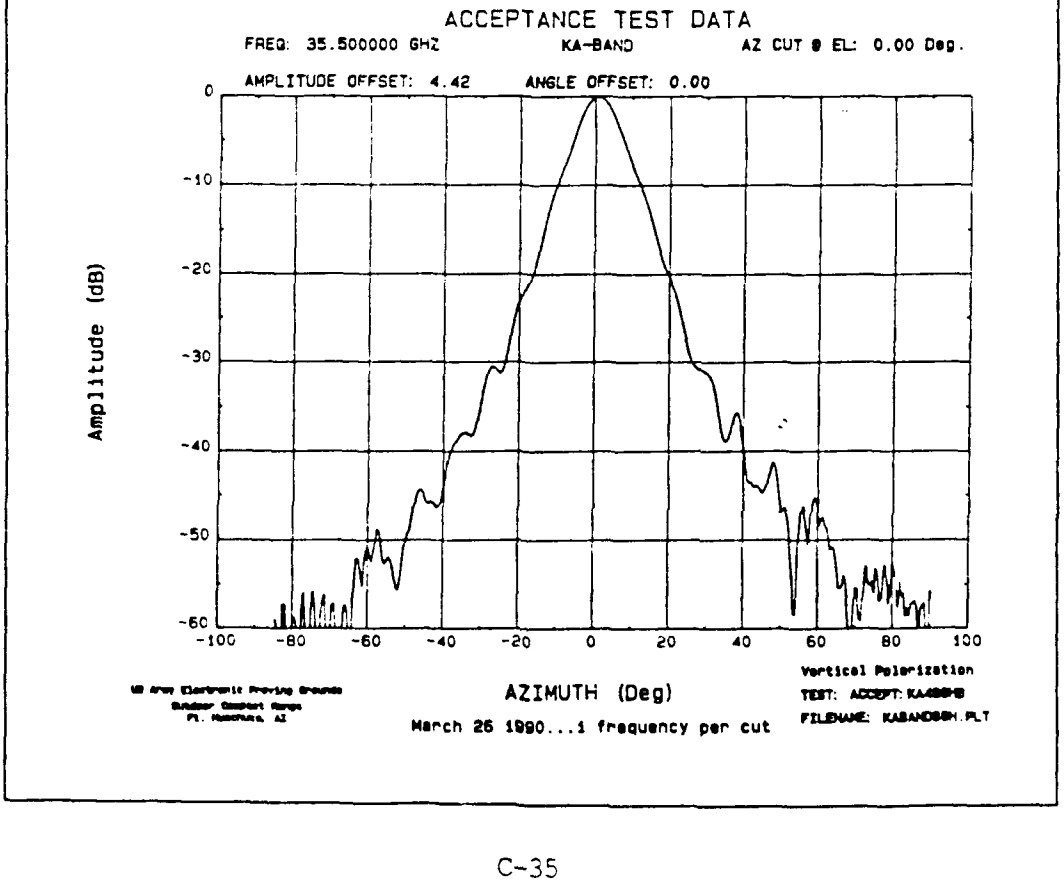

ACCEPTANCE TEST DATA
FREQ: 35.400000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.03
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KABSBH
FILENAME: KABSBH.PLT

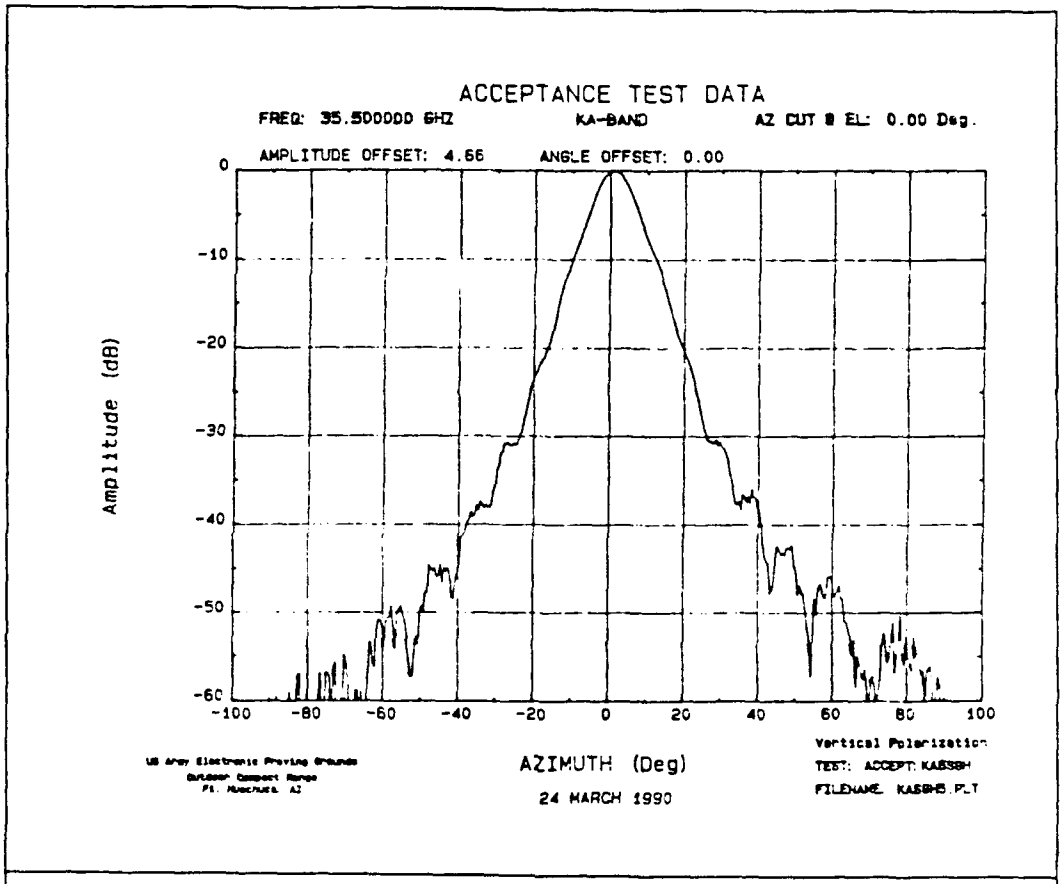

ACCEPTANCE TEST DATA
FREQ: 35.400000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 3.87
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KABSBHB
FILENAME: KABANDBSH.PLT

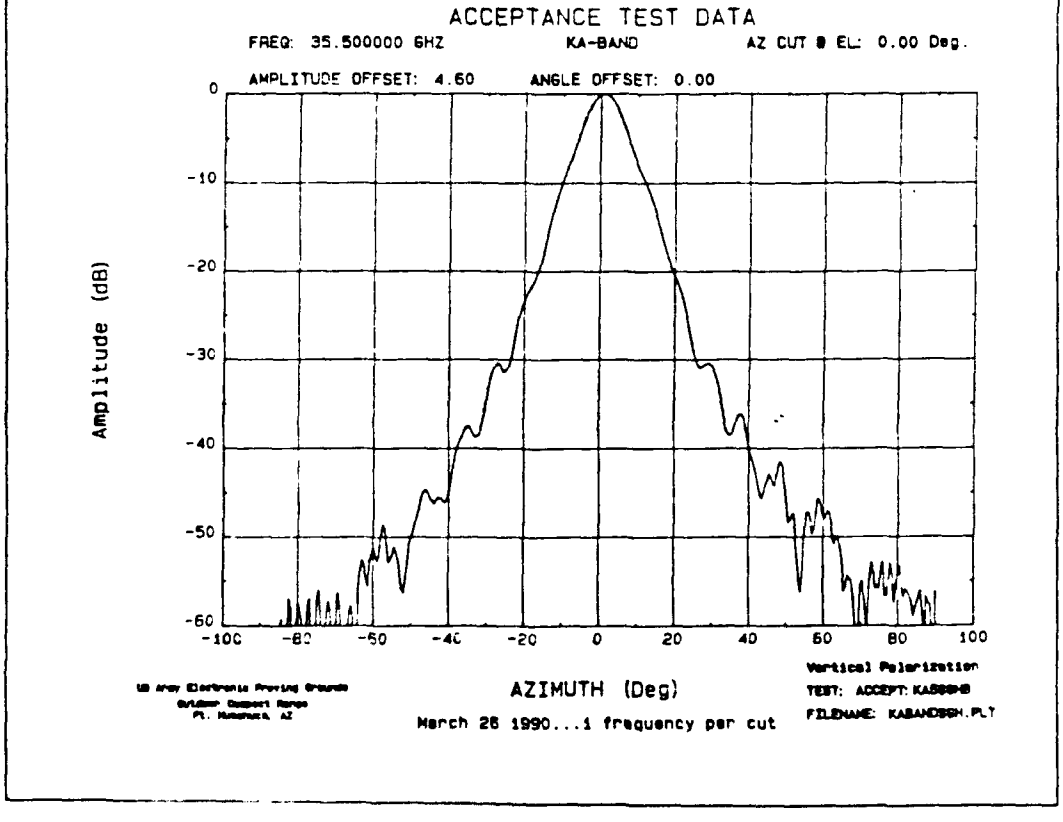

ACCEPTANCE TEST DATA
FREQ: 35.400000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.30
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA7BSH
FILENAME: KABSH7.PLT

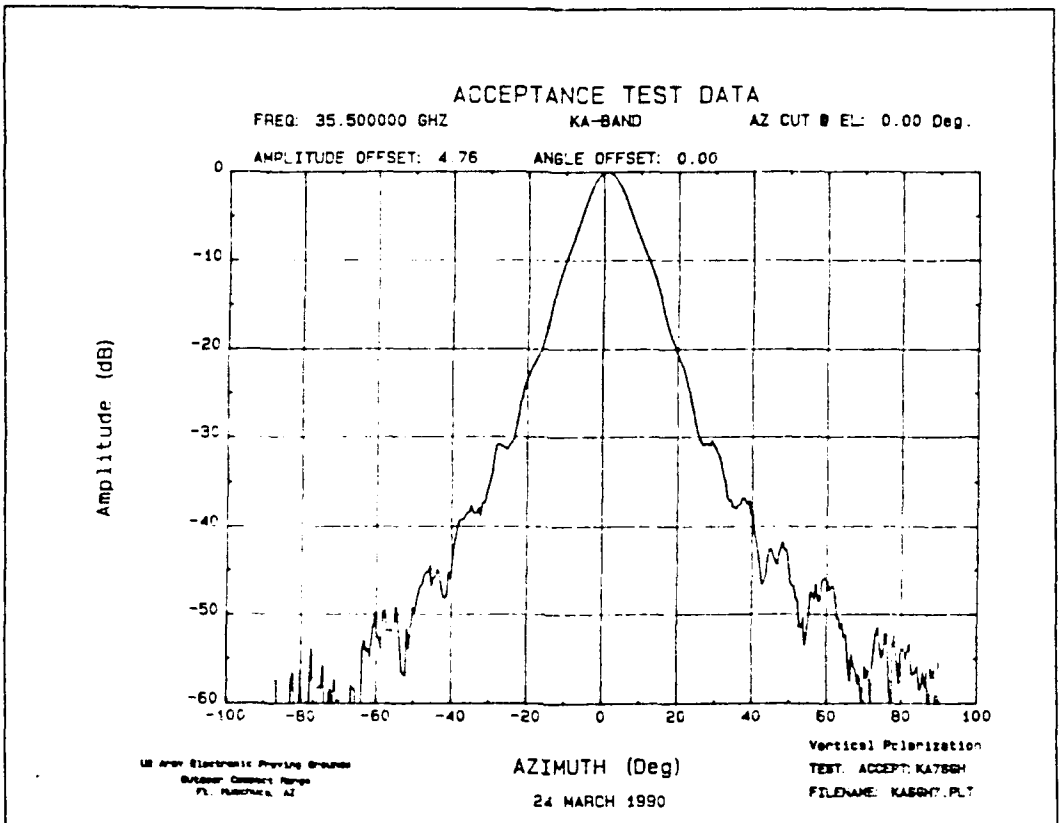

ACCEPTANCE TEST DATA
FREQ: 35.400000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 3.97
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KA7BSHB
FILENAME: KABANDBSH.PLT

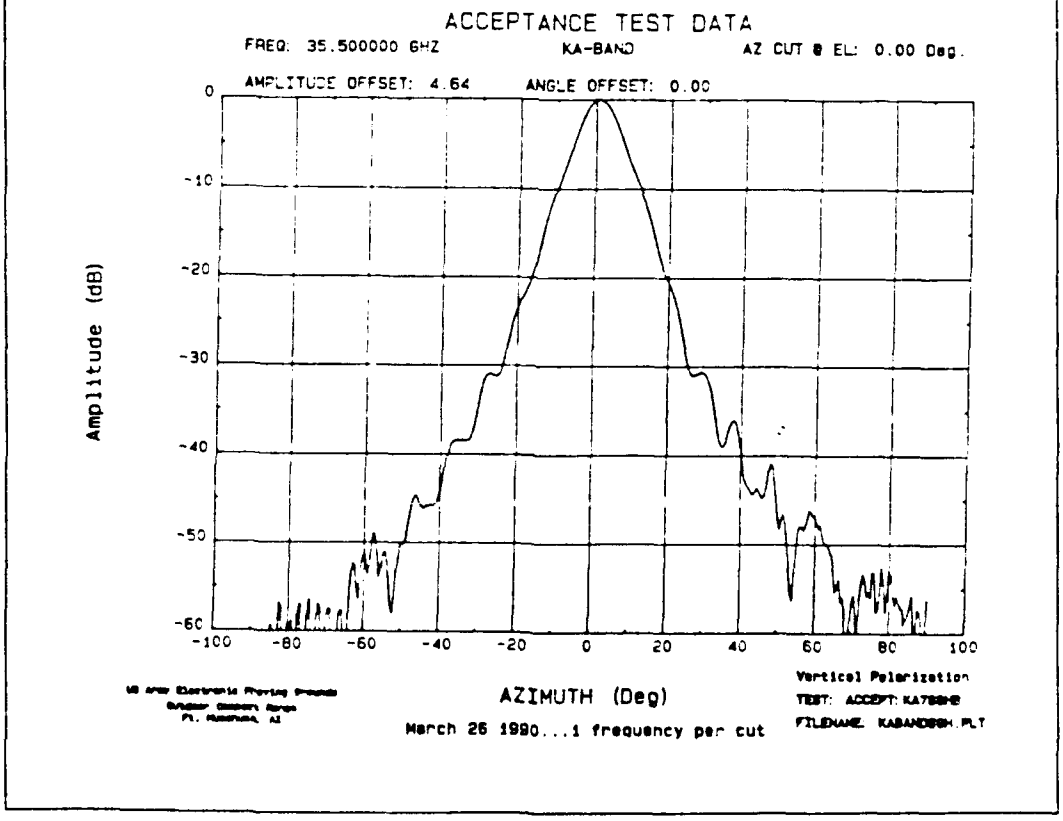

ACCEPTANCE TEST DATA
FREQ: 35.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.51
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA45BH
FILENAME: KA50BH4.PLT

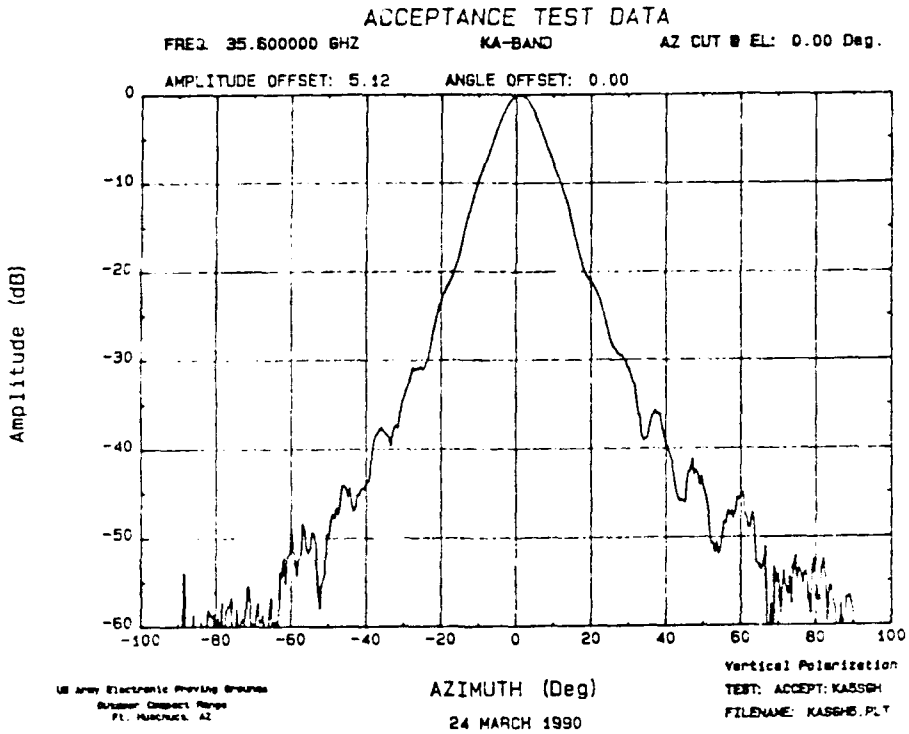

ACCEPTANCE TEST DATA
FREQ: 35.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.42
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KA45BH
FILENAME: KA50BH.PLT

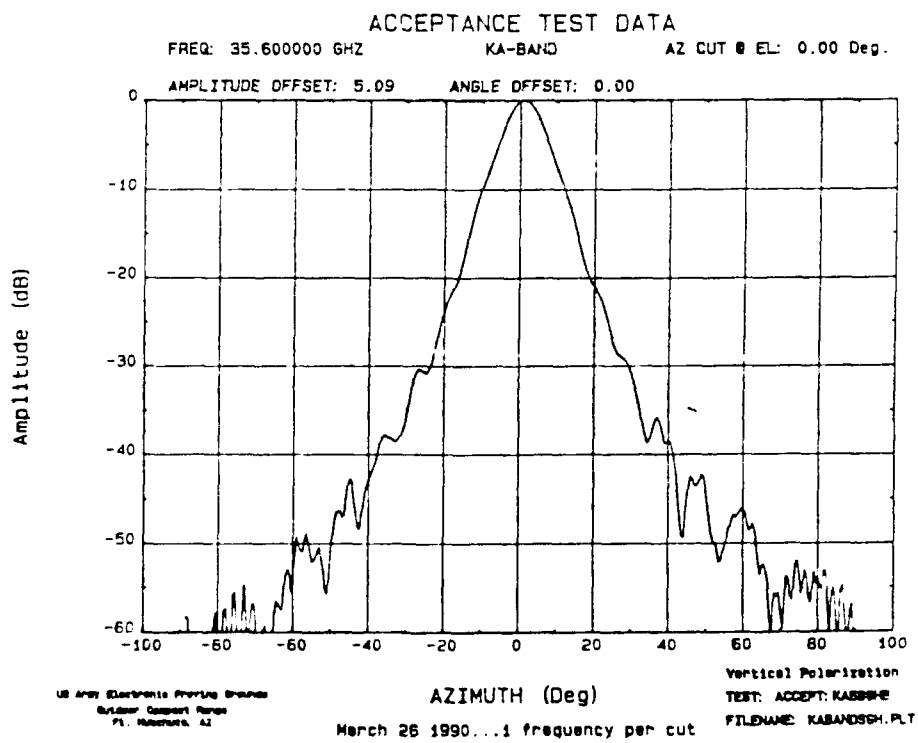

ACCEPTANCE TEST DATA
FREQ: 35.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.66
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT KA8SBH
FILENAME: KA8SBH.PLT

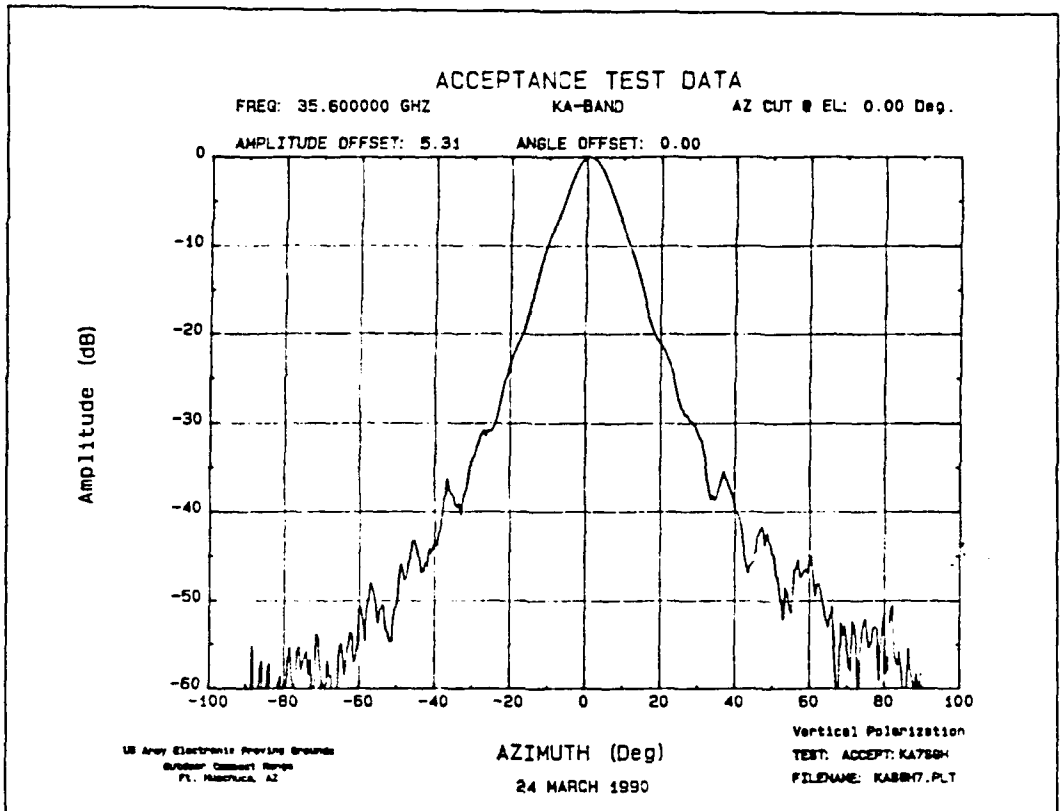

ACCEPTANCE TEST DATA
FREQ: 35.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.60
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization

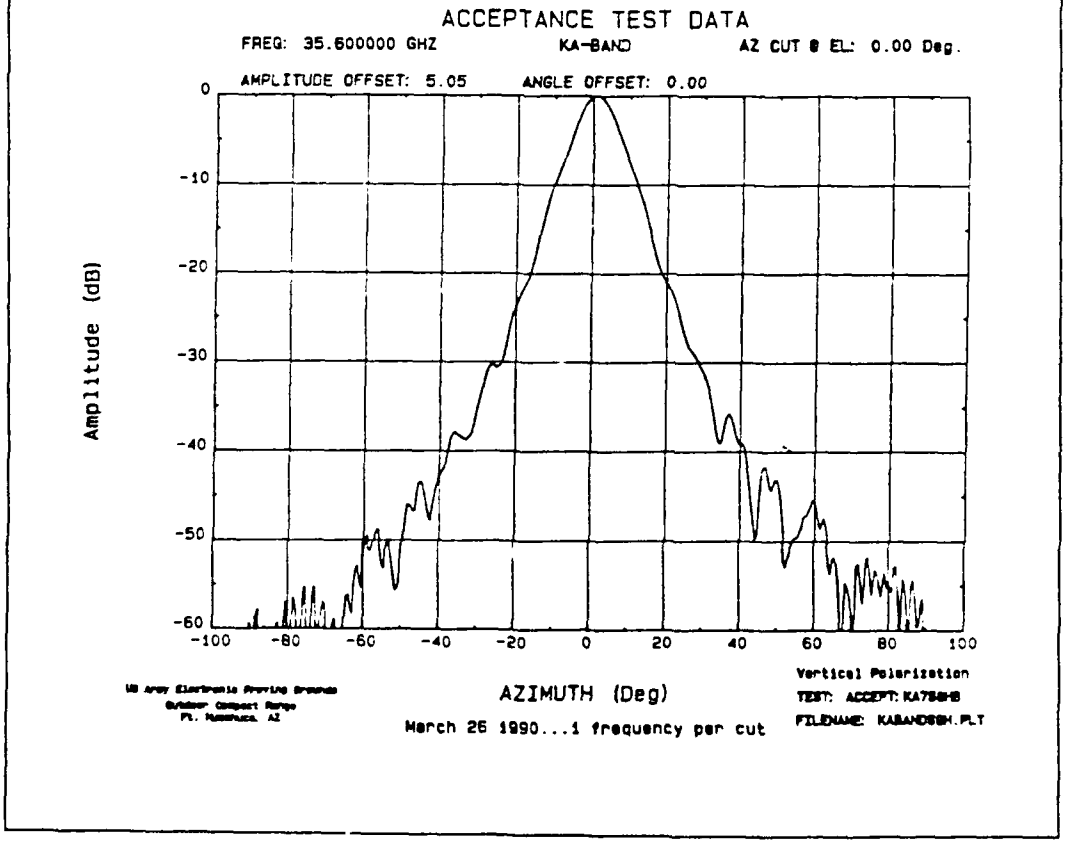

ACCEPTANCE TEST DATA
FREQ: 35.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.76
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT KA7SGH
FILENAME: KASGHT.PLT

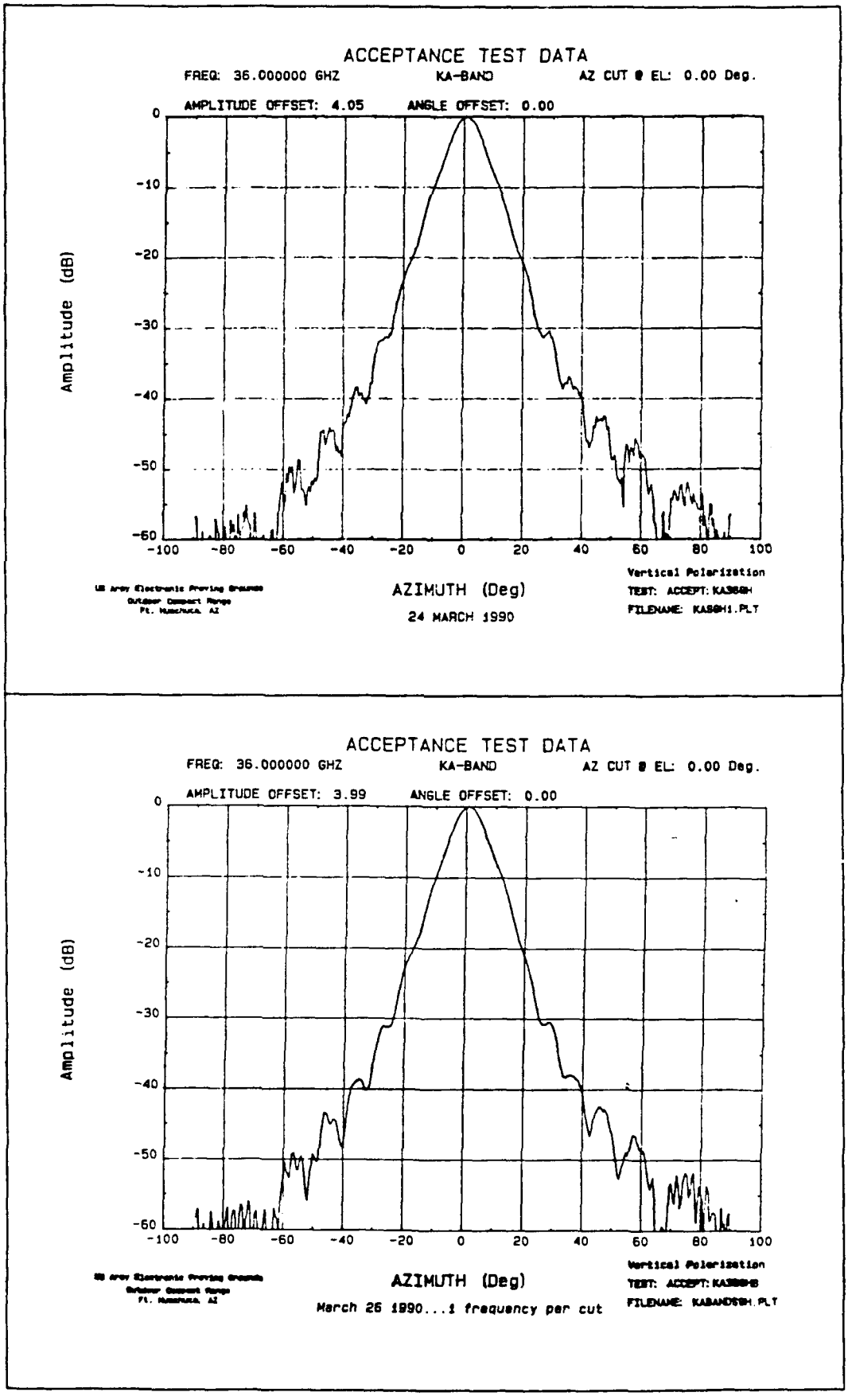

ACCEPTANCE TEST DATA
FREQ: 35.500000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.64
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT KA7SGHZ
FILENAME: KASANDSGH.PLT

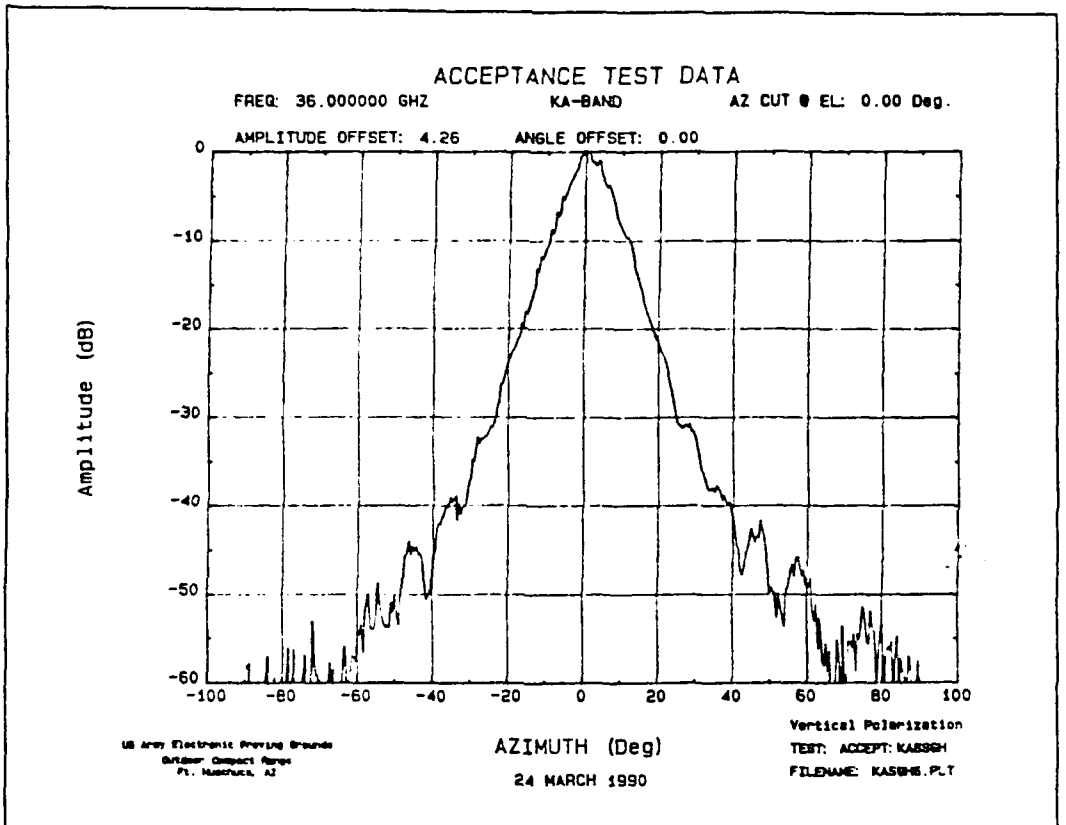

ACCEPTANCE TEST DATA
FREQ. 35.600000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.12
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA5SGH
FILENAME: KA5GH5.PLT

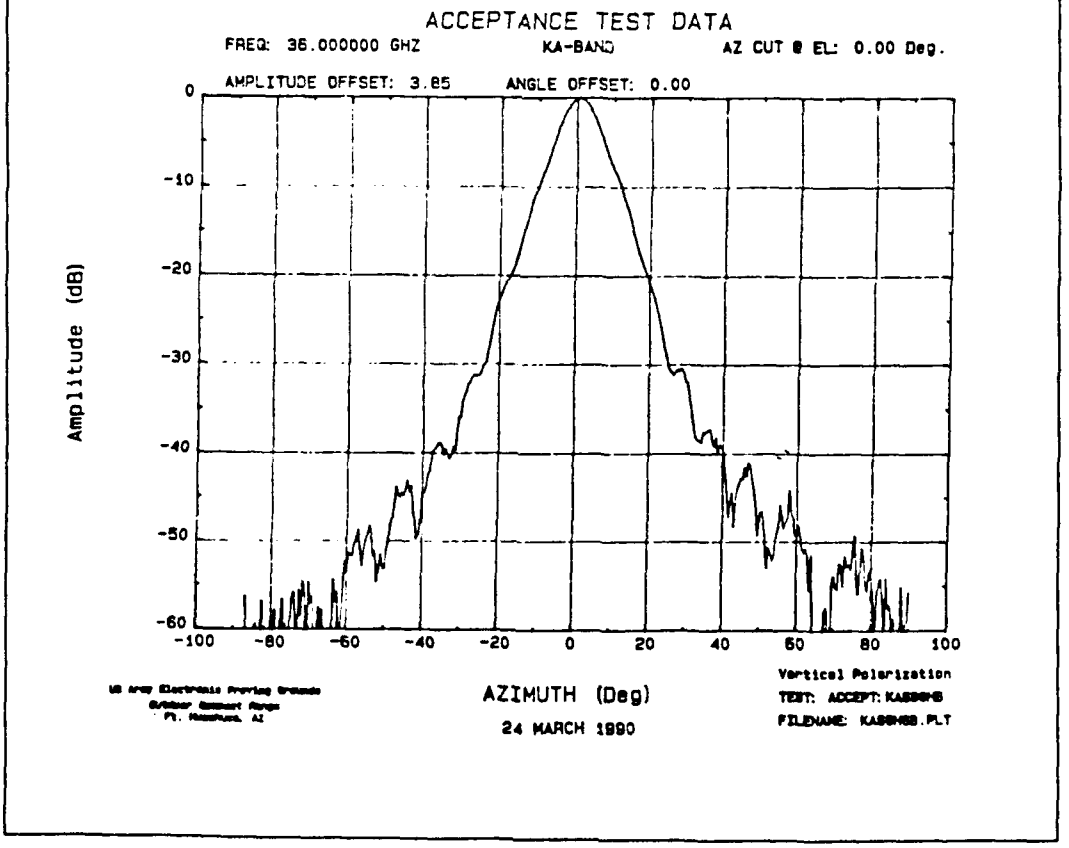

ACCEPTANCE TEST DATA
FREQ: 35.600000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.09
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KA5SGH2
FILENAME: KABANDSGH.PLT

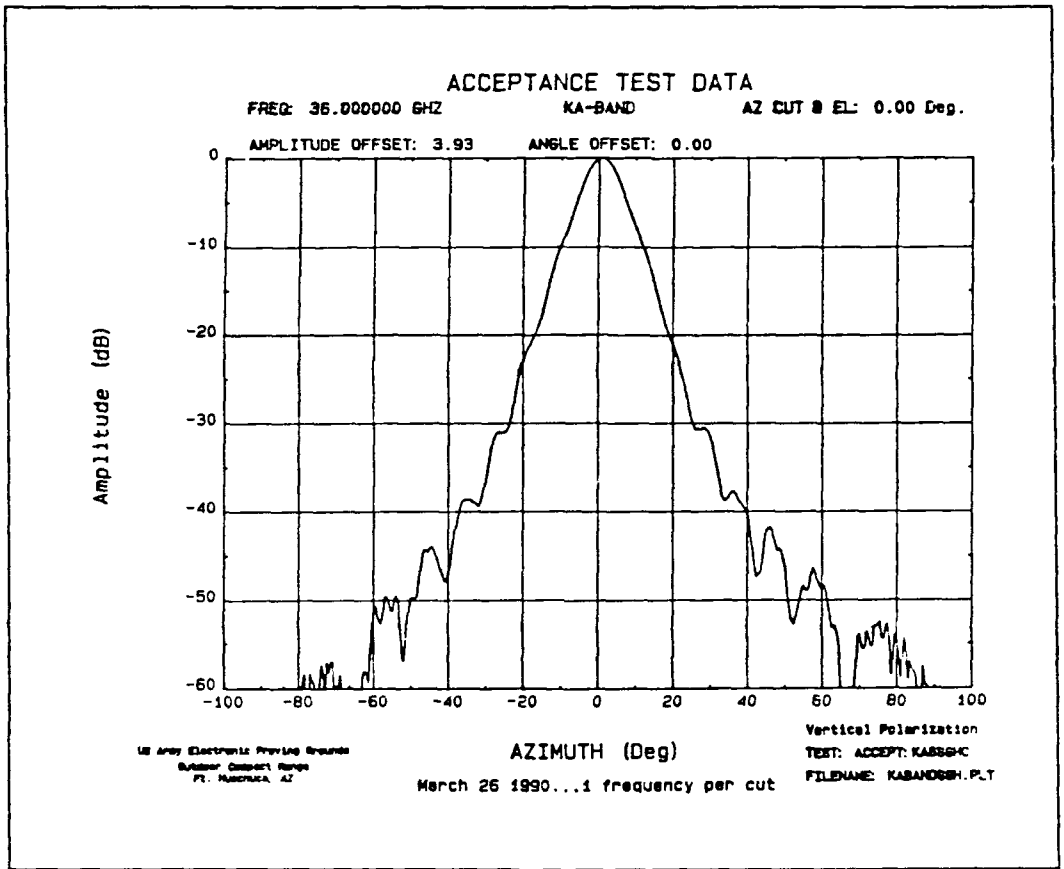

ACCEPTANCE TEST DATA
FREQ: 35.600000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.31
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA7
FILENAME: KA

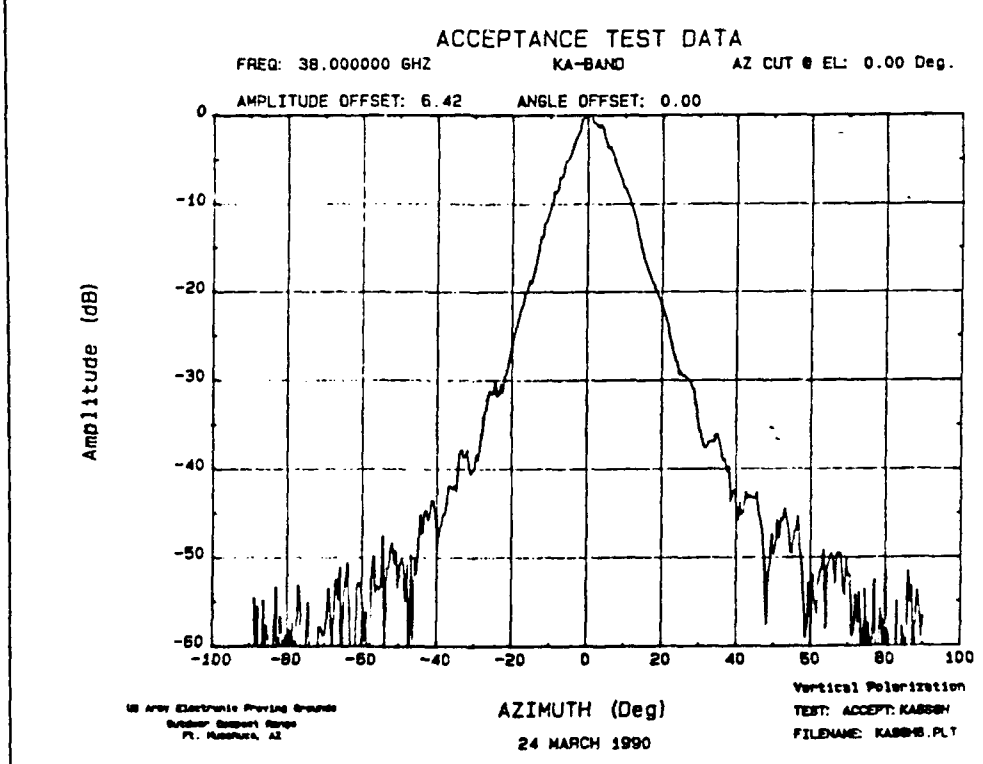

ACCEPTANCE TEST DATA
FREQ: 35.600000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.05
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KA7
FILENAME: KA

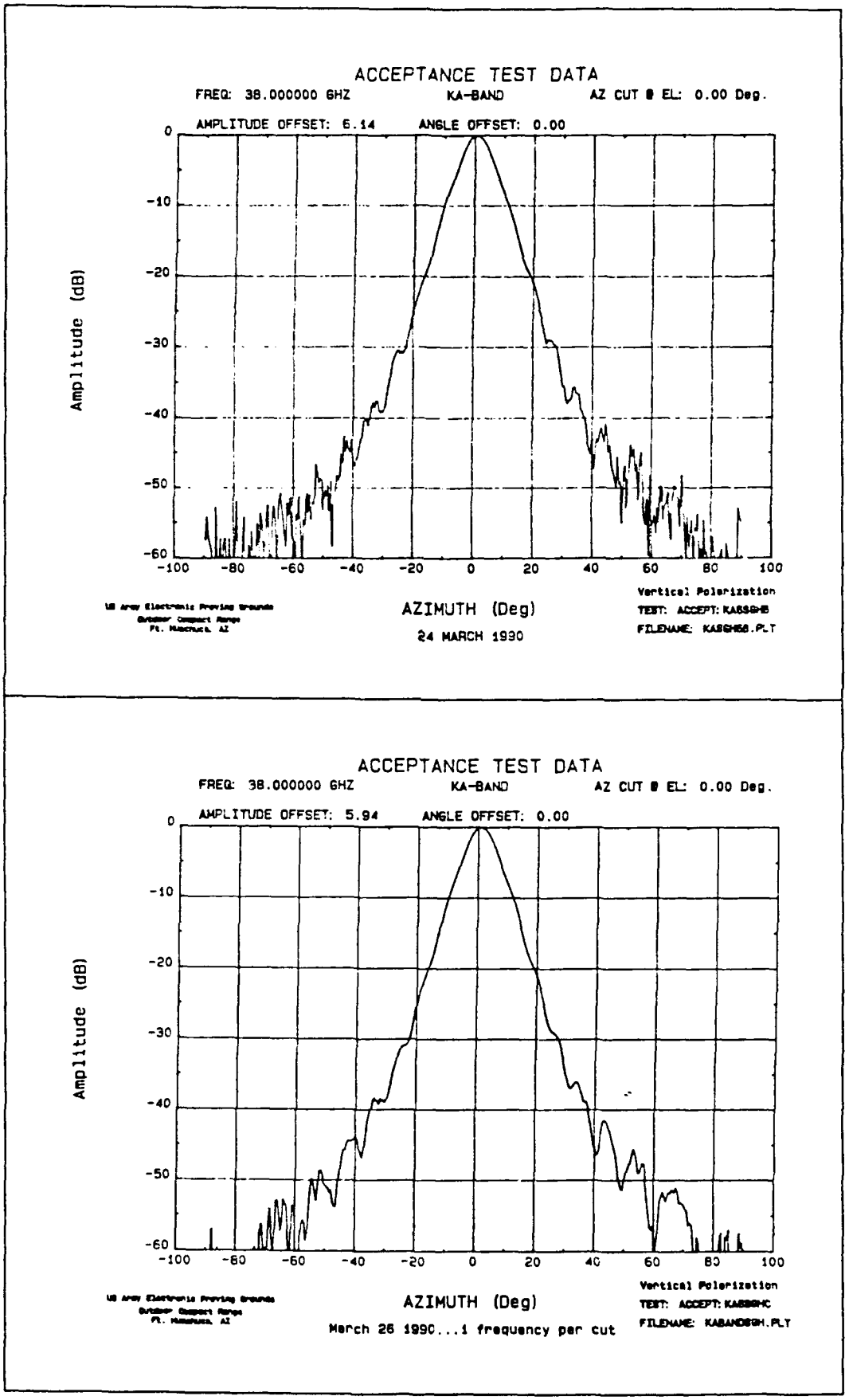

ACCEPTANCE TEST DATA
FREQ: 36.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.05
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA36GH
FILENAME: KA36Hi.PLT
ACCEPTANCE TEST DATA
FREQ: 36.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 3.99
ANGLE OFFSET: 0.00
Amplitude (dB)
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization

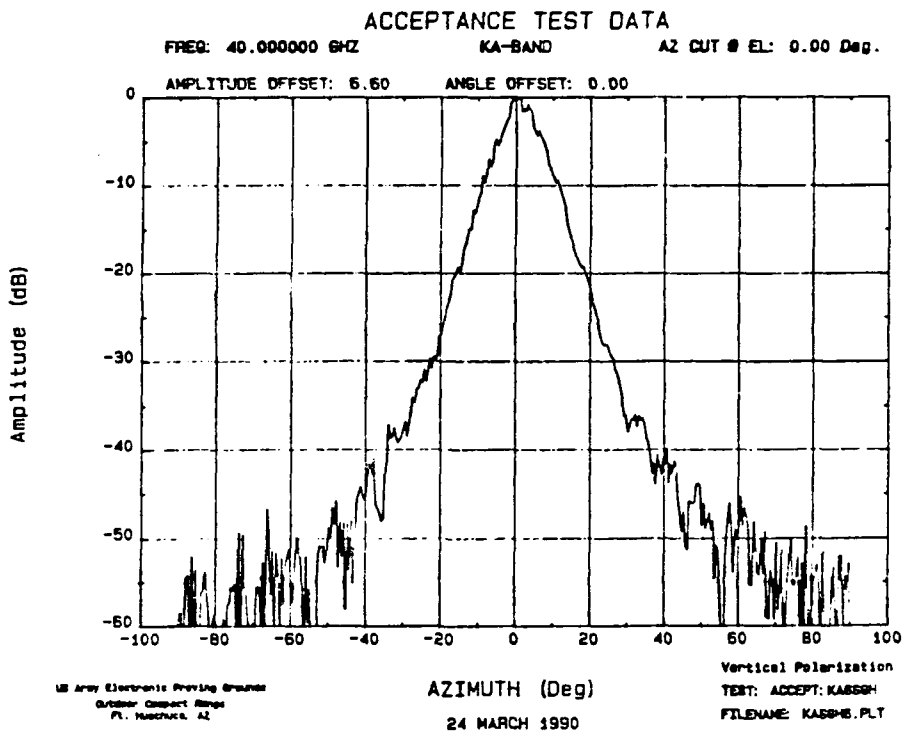

ACCEPTANCE TEST DATA
FREQ: 36.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 4.26
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KASSGH
FILENAME: KASGHS.PLT

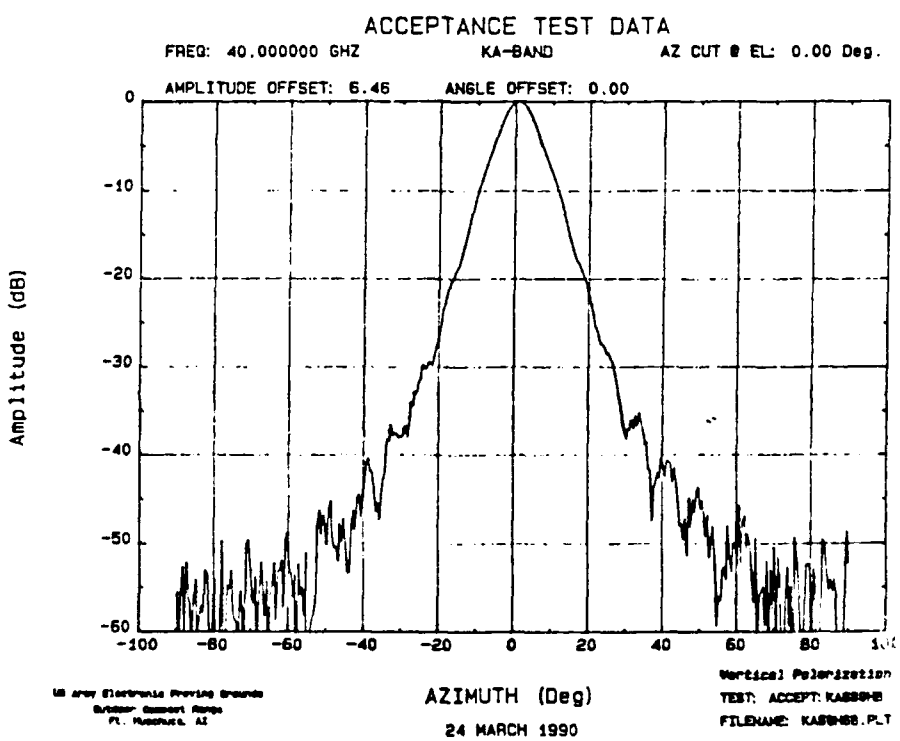

ACCEPTANCE TEST DATA
FREQ: 36.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 3.85
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization

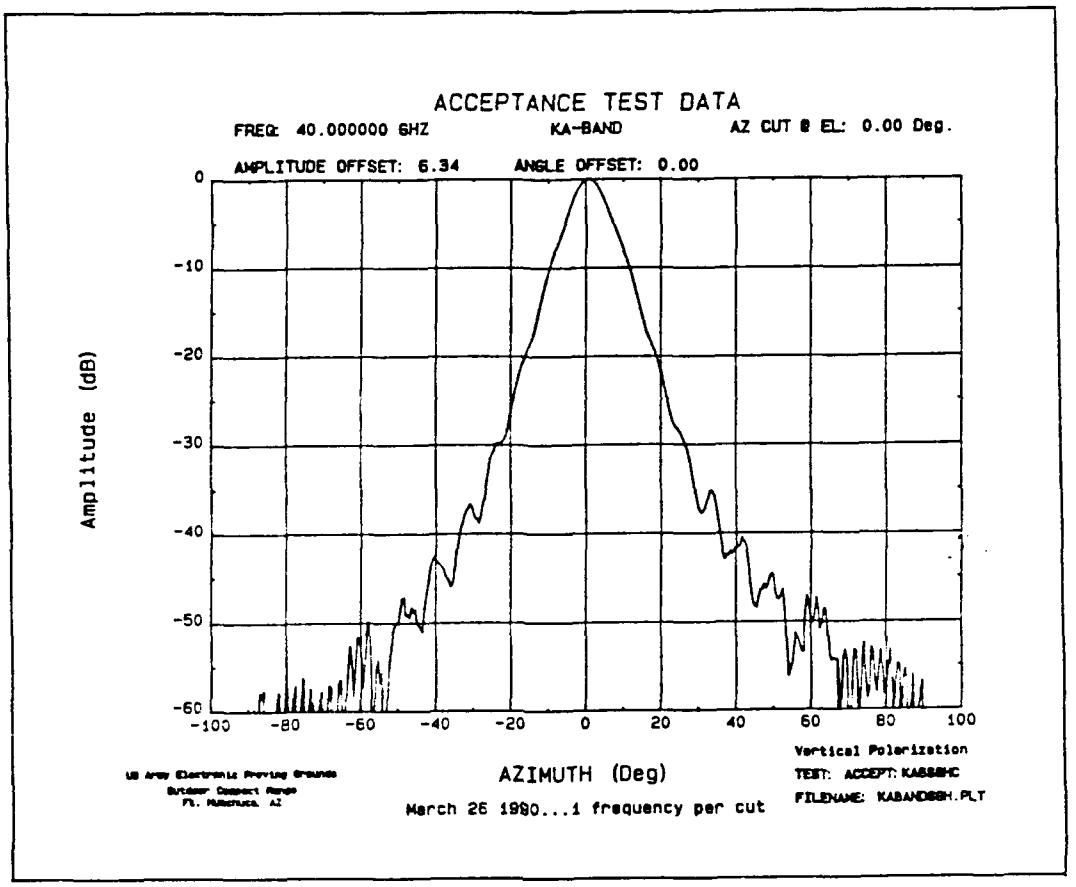

ACCEPTANCE TEST DATA
FREQ: 36.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 3.93
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
Vertical Polarization
TEST: ACCEPT: KABSGHC
FILENAME: KABANDSGH.PLT
March 26 1990...1 frequency per cut


ACCEPTANCE TEST DATA
FREQ: 38.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 6.42
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
Vertical Polarization
TEST: ACCEPT: KABSGH
24 MARCH 1990


ACCEPTANCE TEST DATA
FREQ: 38.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 6.14
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KASSHB
FILENAME: KASSH58.PLT
ACCEPTANCE TEST DATA
FREQ: 38.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 5.94
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
March 26 1990...1 frequency per cut
Vertical Polarization
TEST: ACCEPT: KABBHC
FILENAME: KABANDBH.PLT


ACCEPTANCE TEST DATA
FREQ: 40.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 6.60
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA6SGH
FILENAME: KA6SH6.PLT


ACCEPTANCE TEST DATA
FREQ: 40.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 6.46
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
AZIMUTH (Deg)
24 MARCH 1990
Vertical Polarization
TEST: ACCEPT: KA6SGHB
FILENAME: KA6SH6B.PLT


ACCEPTANCE TEST DATA
FREQ: 40.000000 GHZ
KA-BAND
AZ CUT @ EL: 0.00 Deg.
AMPLITUDE OFFSET: 6.34
ANGLE OFFSET: 0.00
Amplitude (dB)
0
-10
-20
-30
-40
-50
-60
-100
-80
-60
-40
-20
0
20
40
60
80
100
AZIMUTH (Deg)
Vertical Polarization
TEST: ACCEPT: KABBIHC
FILENAME: KABANDBBH.PLT
March 26 1990...1 frequency per cut

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APPENDIX D. PHOTOGRAMMETRIC MEASUREMENTS

This appendix summarizes, in graphical form, photogrammetric measures of the accuracy of the Compact Range's parabolic reflector. These graphics a e from a report prepared by Geodetic Services Inc. of Melbourne, Florida. The entire photogrammetric data set, consisting of more than 200 pages of three-dimensional data in tabular form, is on file at USAEPG.

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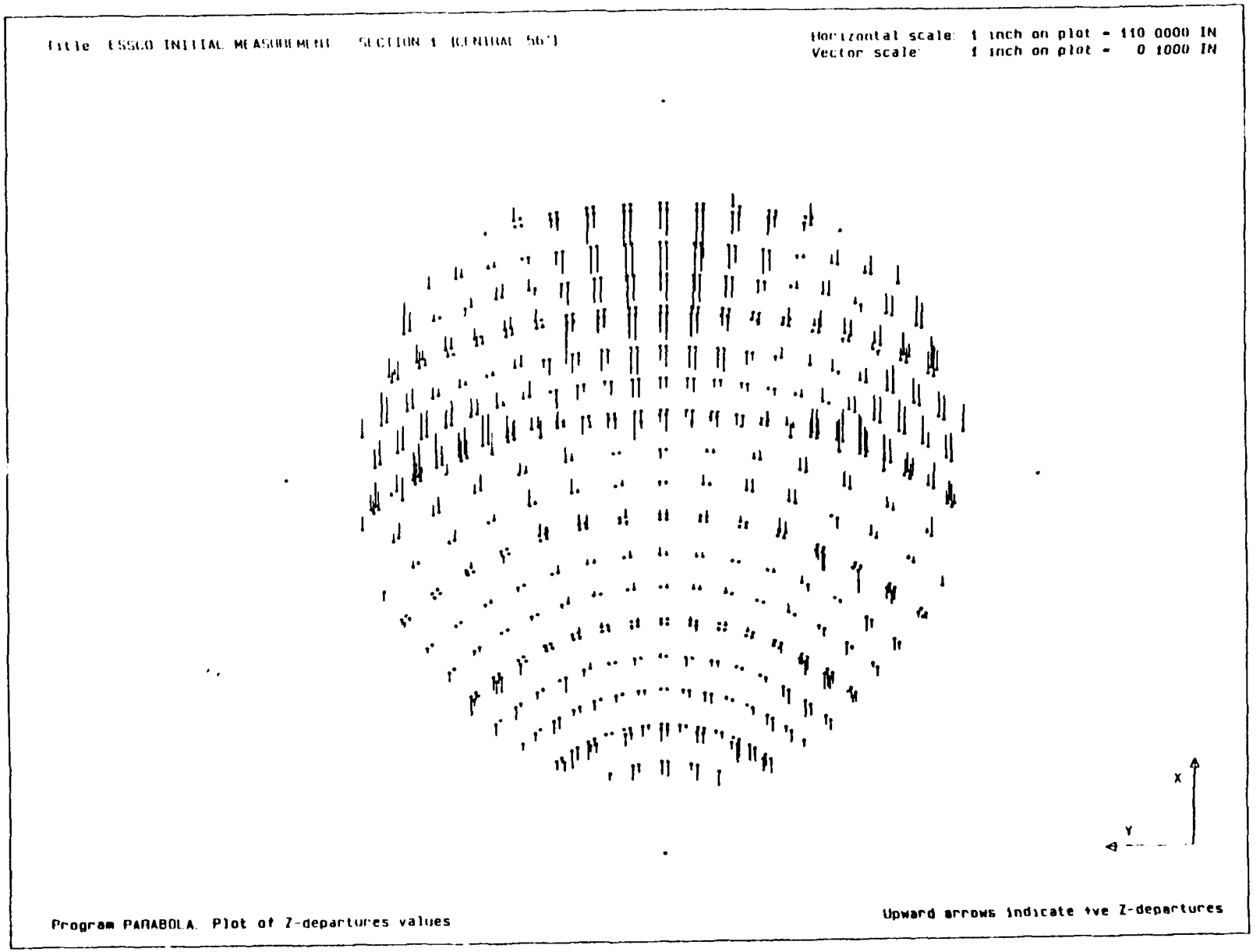
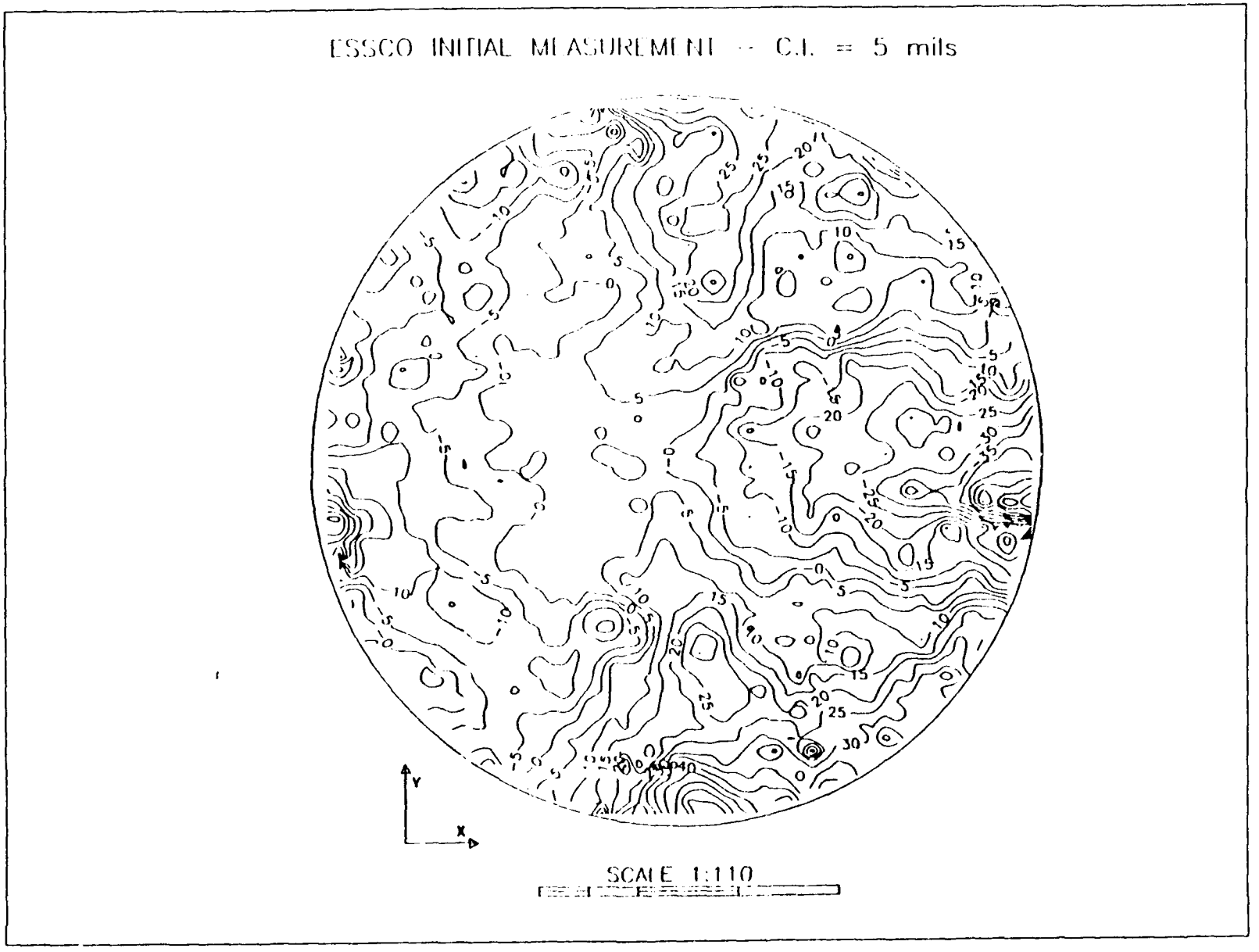
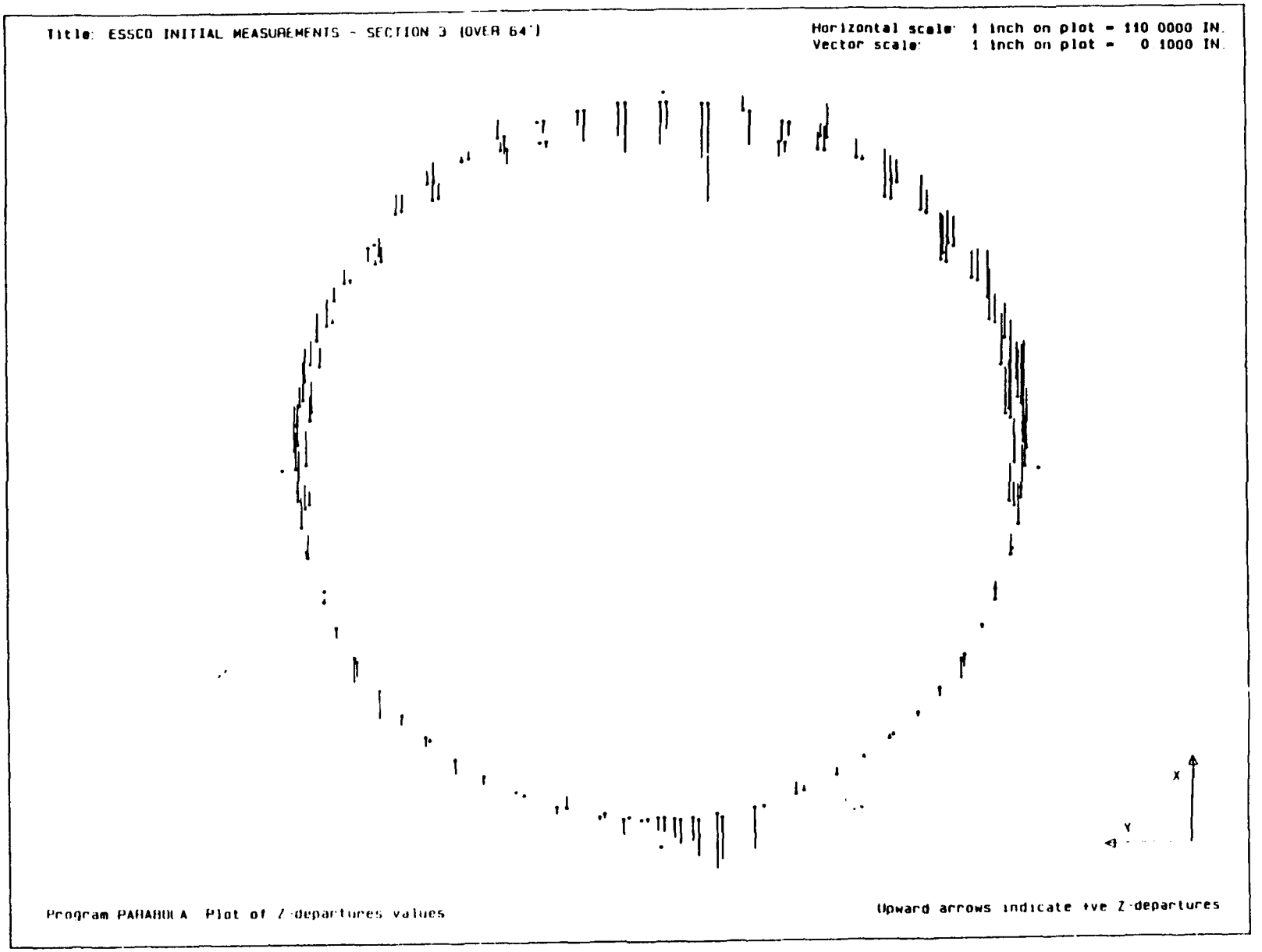
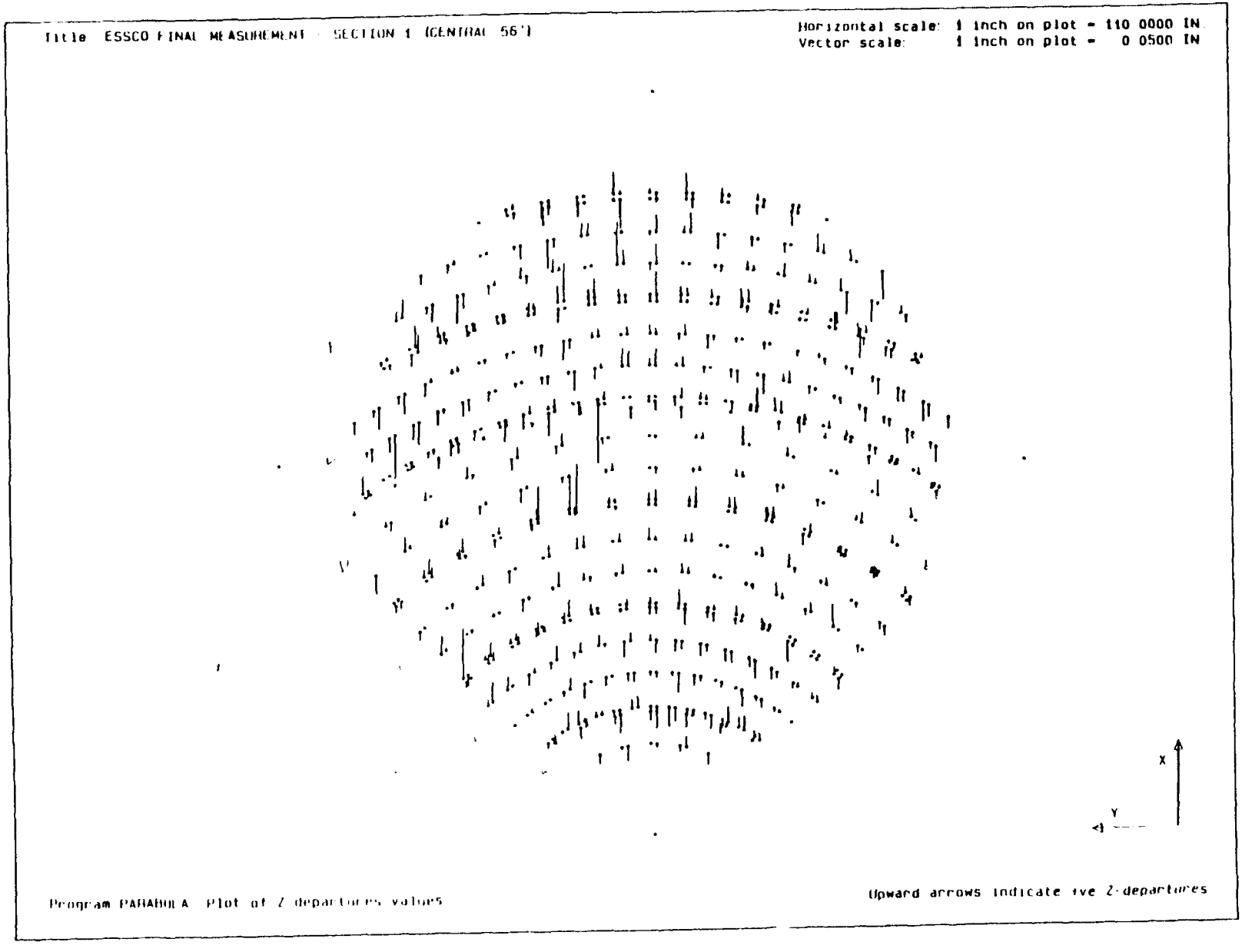
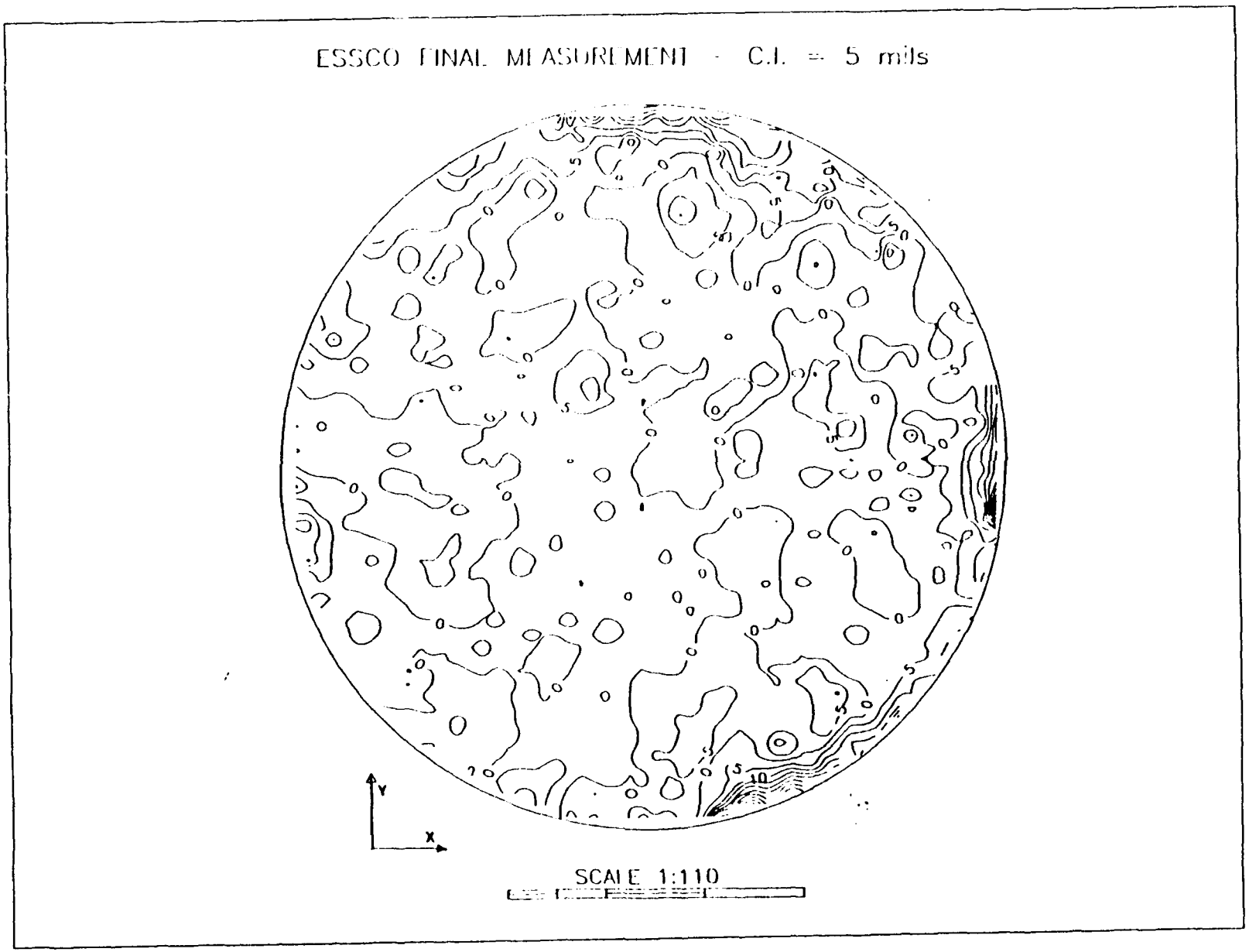
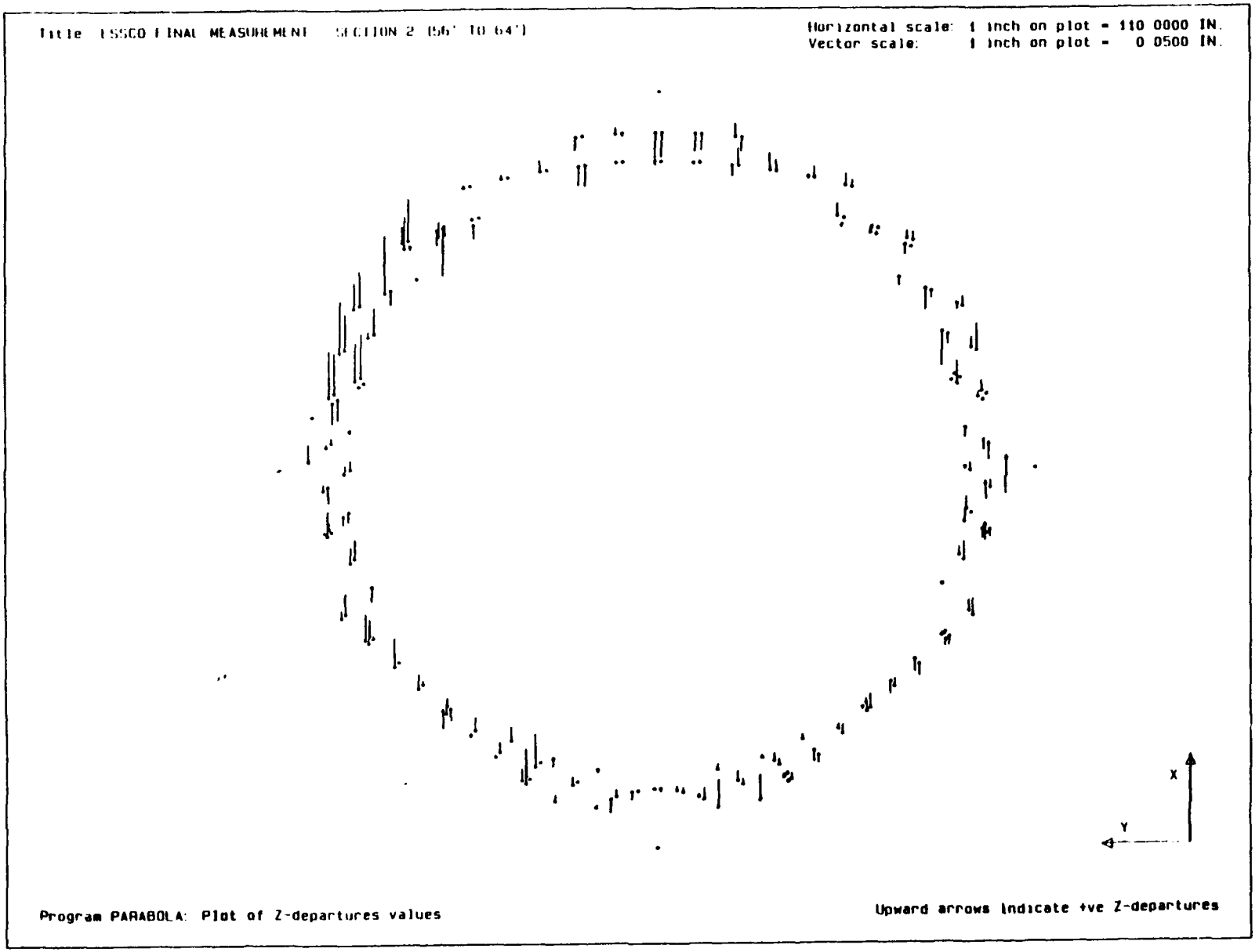

Title ESSCO INITIAL MEASUREMENT SECTION 1 (CENTRAL 56')
Horizontal scale: 1 inch on plot = 110 0000 IN
Vector scale: 1 inch on plot = 0 1000 IN
X
Y
Program PARABOLA. Plot of Z-departures values
Upward arrows indicate +ve Z-departures

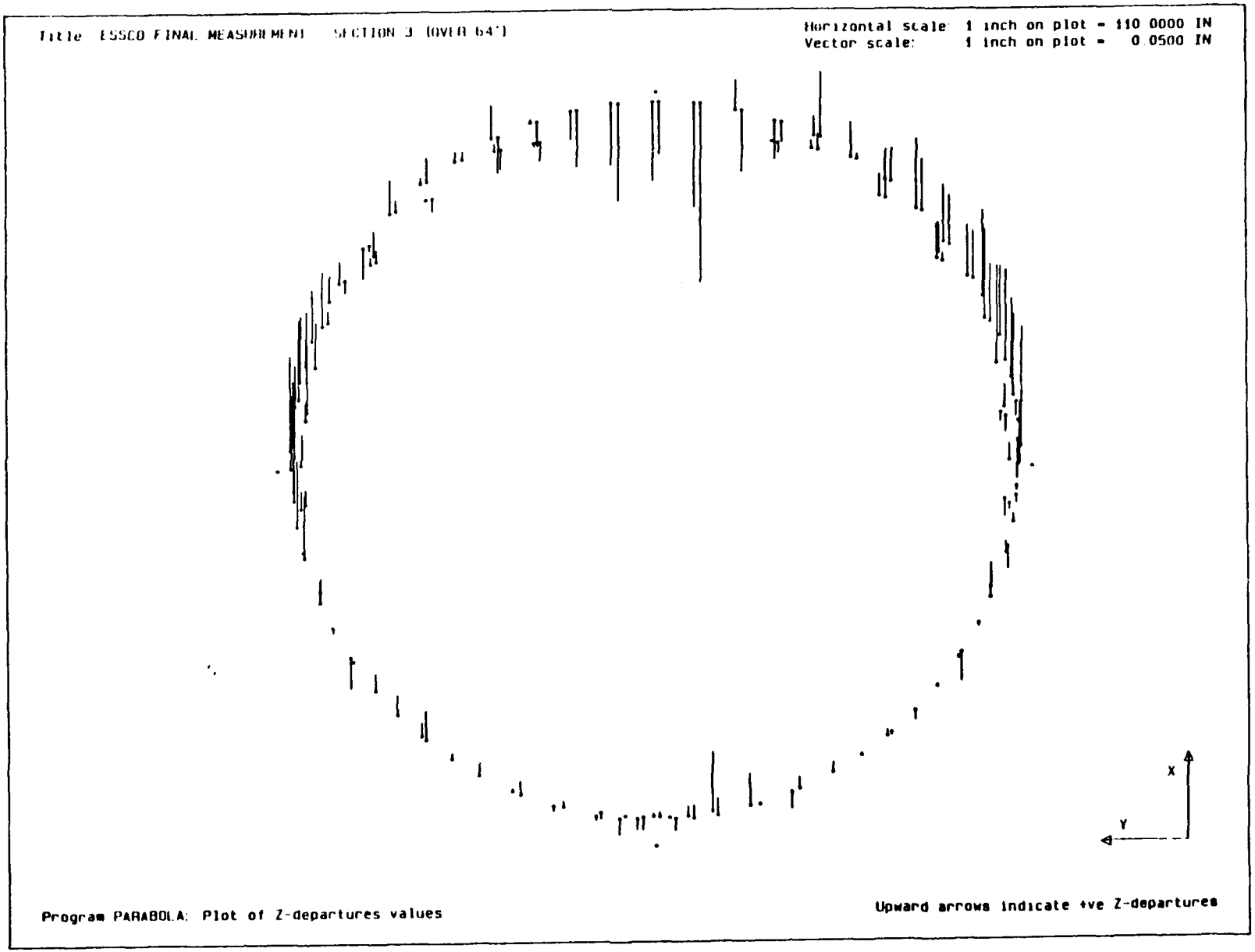

ESSCO INITIAL MEASUREMENT -- C.I. = 5 mils
Y
X
SCALE 1:110

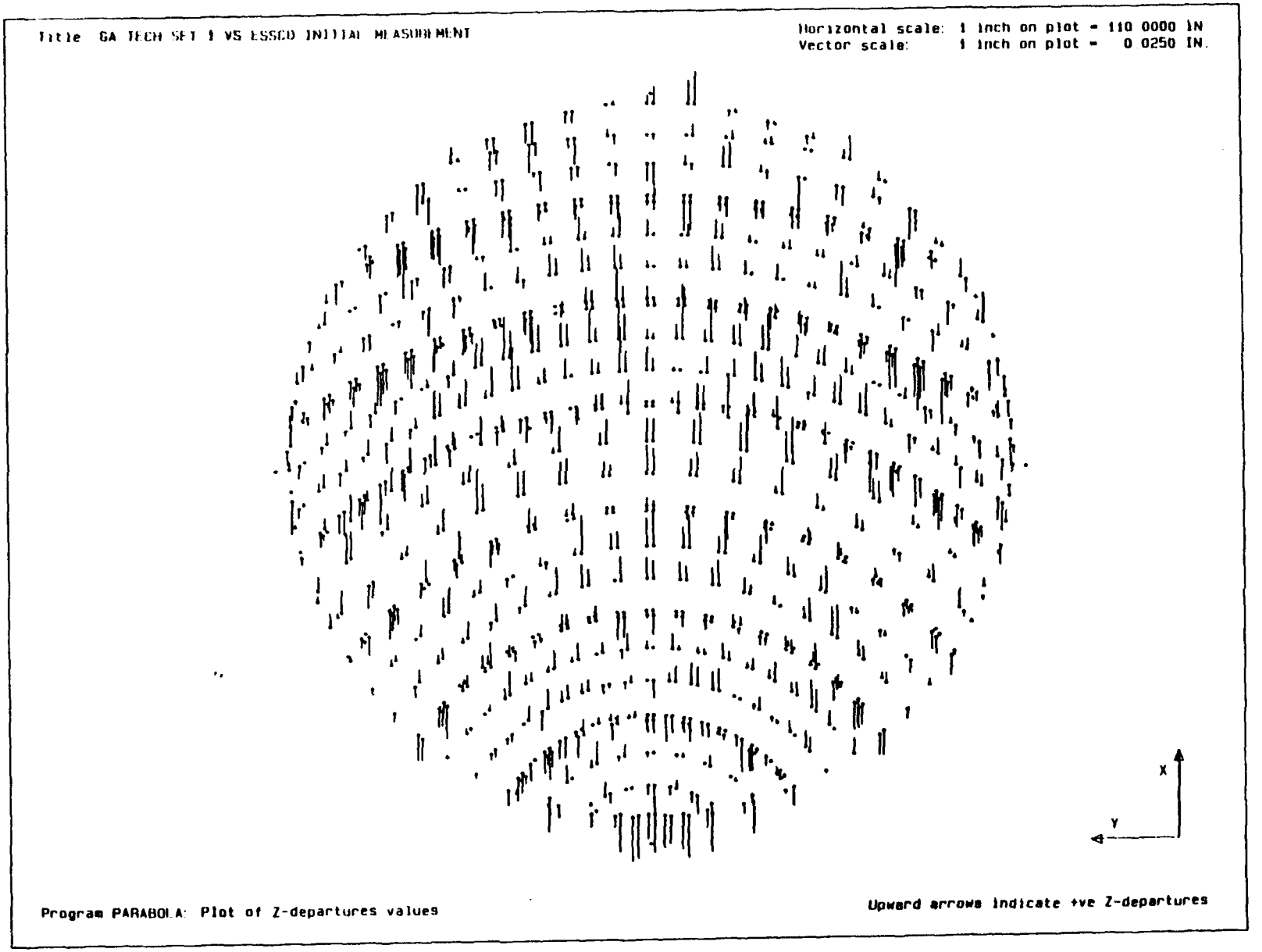

Title: ESSCO INITIAL MEASUREMENTS - SECTION 3 (OVER 64')
Horizontal scale: 1 inch on plot = 110 0000 IN.
Vector scale: 1 inch on plot = 0 1000 IN.
X
Y
Program PARABOLA Plot of Z-departures values
Upward arrows indicate +ve Z-departures

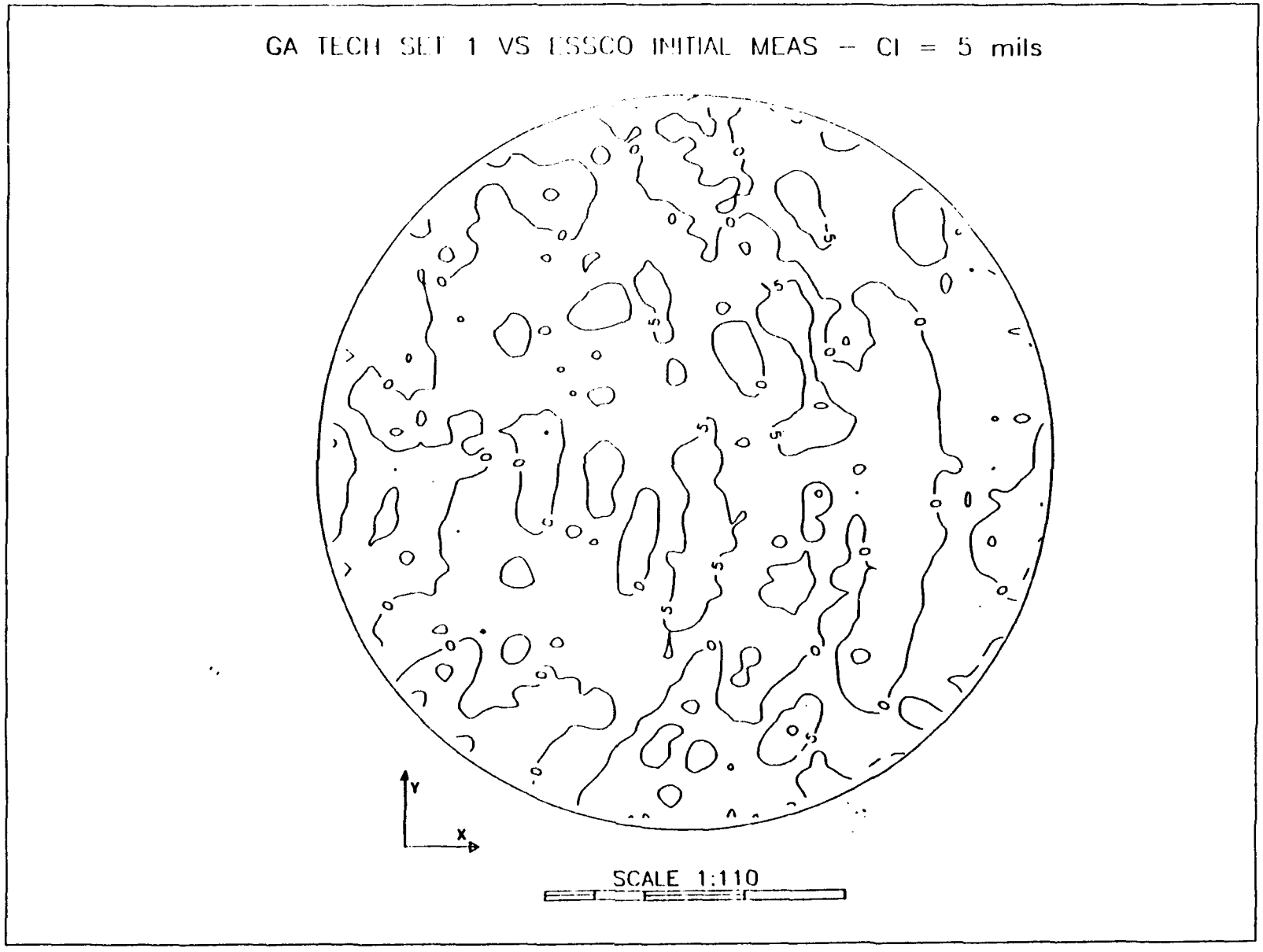

Title ESSCO FINAL MEASUREMENT - SECTION 1 (CENTRAL 56')
Horizontal scale: 1 inch on plot = 110 0000 IN
Vector scale: 1 inch on plot = 0 0500 IN
X
Y
Program PARABOLA Plot of Z departures values
Upward arrows indicate +ve Z-departures

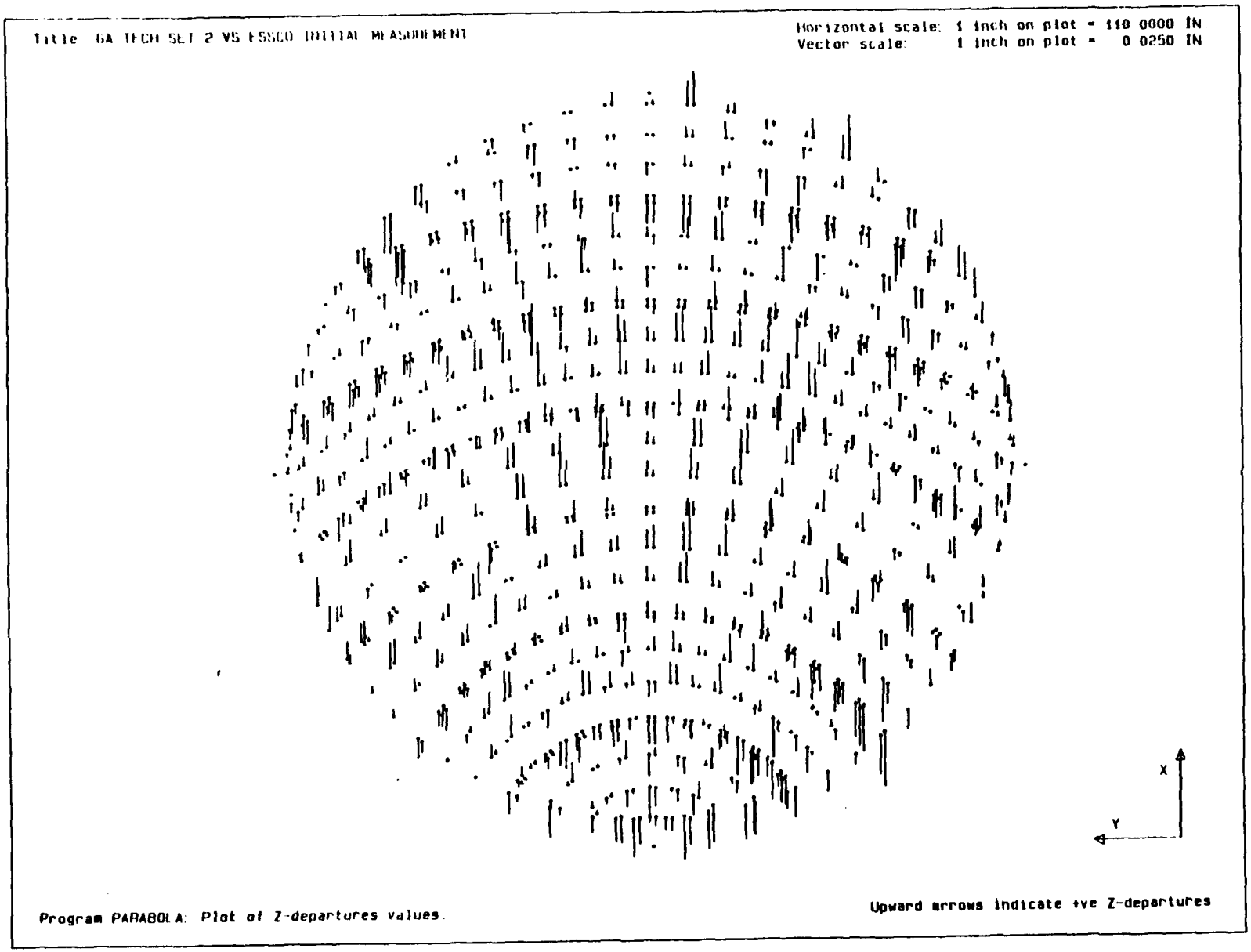

ESSCO FINAL MEASUREMENT - C.I. = 5 mils
Y
X
SCALE 1:110

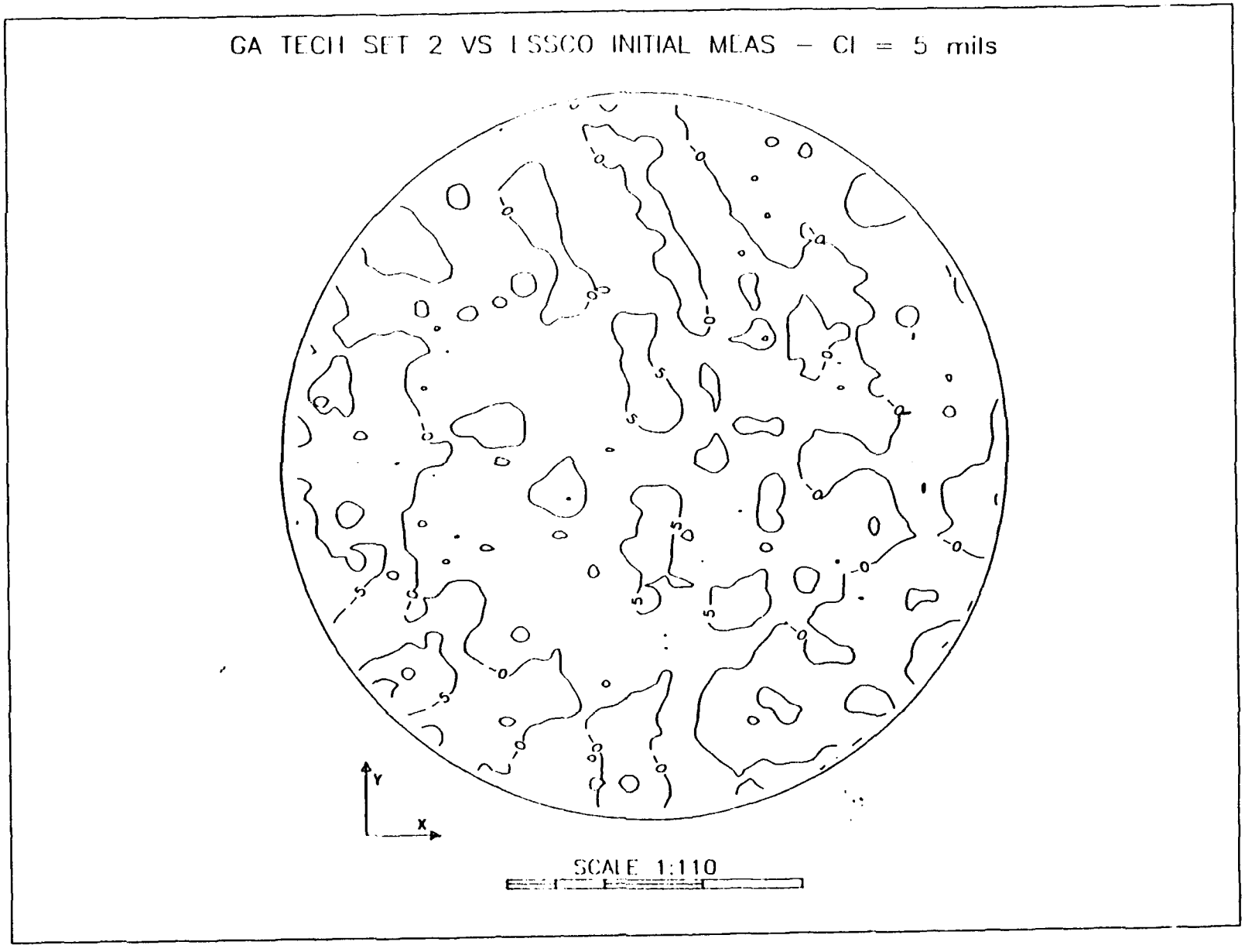

Title ESSCO FINAL MEASUREMENT SECTION 2 (56' TO 64')
Horizontal scale: 1 inch on plot = 110 0000 IN.
Vector scale: 1 inch on plot = 0 0500 IN.
X
Y
Program PARABOLA: Plot of Z-departures values
Upward arrows indicate +ve Z-departures

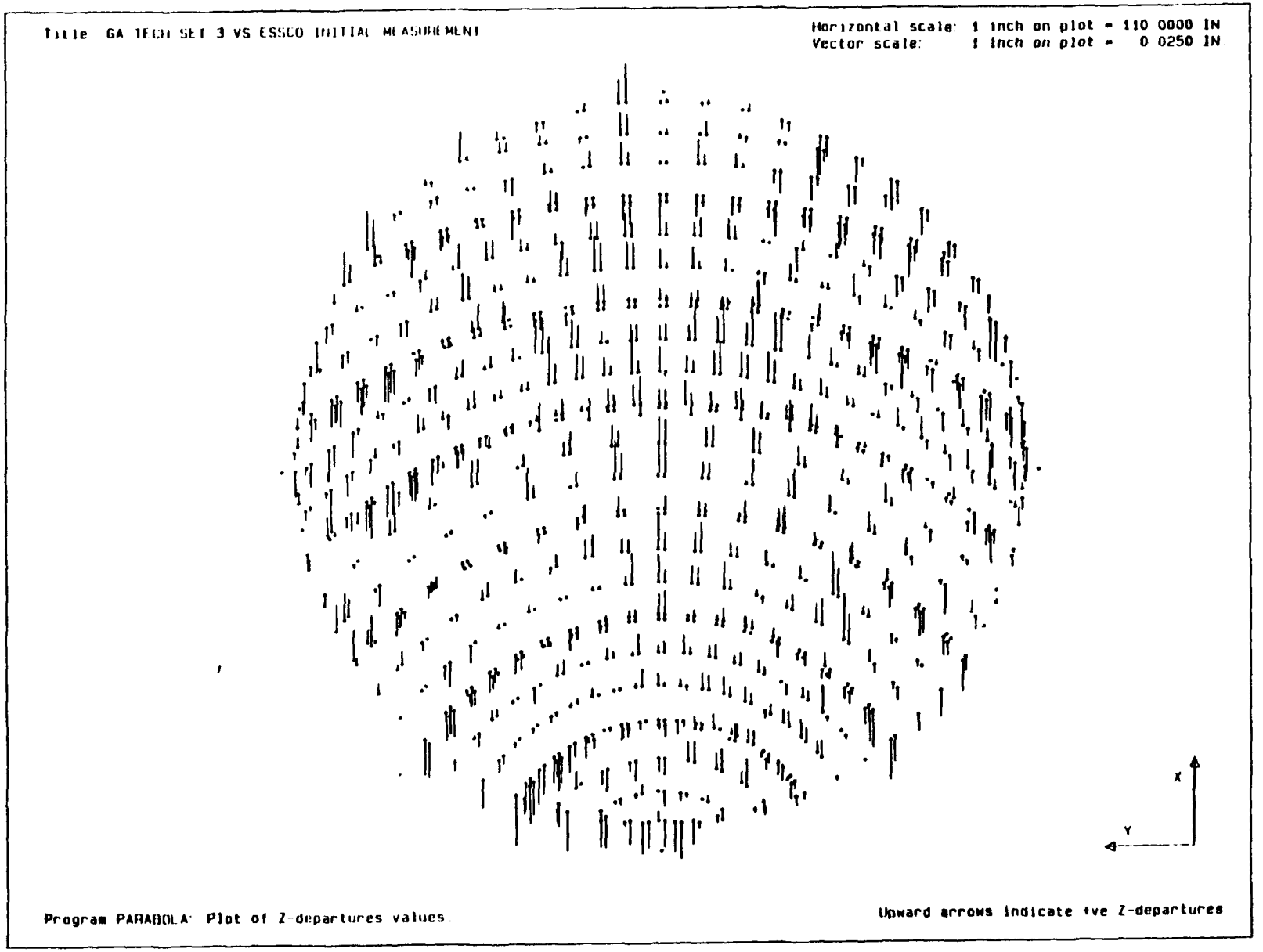

Title ESSCO FINAL MEASUREMENT SECTION 3 (OVER 64")
Horizontal scale: 1 inch on plot = 10 0000 IN
Vector scale: 1 inch on plot = 0 0500 IN
X
Y
Program PARABOLA: Plot of Z-departures values
Upward arrows indicate +ve Z-departures

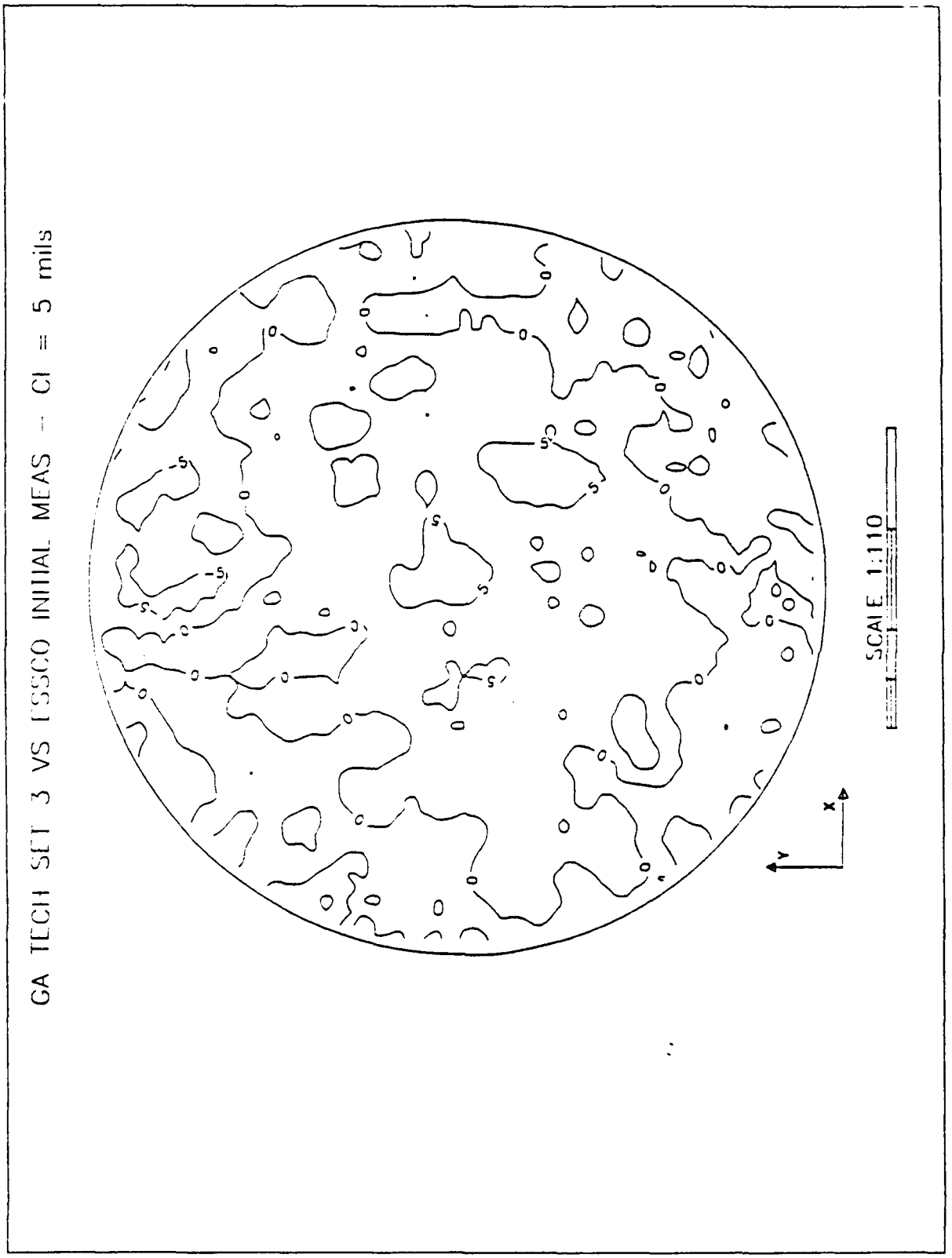

Title GA TECH SET 1 VS ESSCO INITIAL MEASUREMENT
Horizontal scale: 1 inch on plot = 110 0000 IN
Vector scale: 1 inch on plot = 0 0250 IN.
X
Y
Program PARABOLA: Plot of Z-departures values
Upward arrows indicate +ve Z-departures


GA TECH SET 1 VS ESSCO INITIAL MEAS -- CI = 5 mils
Y
X
SCALE 1:110


Title GA TECH SET 2 VS ESSCO INITIAL MEASUREMENT
Horizontal scale: 1 inch on plot = 110 0000 IN
Vector scale: 1 inch on plot = 0 0250 IN
X
Y
Program PARABOLA: Plot of Z-departures values.
Upward arrows indicate +ve Z-departures


GA TECH SET 2 VS ISSCO INITIAL MEAS – CI = 5 mils
Y
X
SCALE 1:110


Title GA TECH SET 3 VS ESSCO INITIAL MEASUREMENT
Horizontal scale: 1 inch on plot = 110 0000 IN
Vector scale: 1 inch on plot = 0 0250 IN
X
Y
Program PARABOLA: Plot of Z-departures values.
Upward arrows indicate +ve Z-departures


GA TECH SET 3 VS ESSCO INITIAL MEAS -- CI = 5 mils
SCALE 1:110
X
Y

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APPENDIX E. ACCEPTANCE TEST PLAN FOR THE USAEPG COMPACT RANGE (GTRI)

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ACCEPTANCE TEST PLAN

for

USAEPG COMPACT RANGE

developed under

Contract No. DAEA18-84-C-0050

by

Georgia Tech Research Institute
Georgia Institute of Technology
Atlanta, Georgia 30332

10 January 1990

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ACCEPTANCE TEST PLAN
for
USAEPG COMPACT RANGE

1 INTRODUCTION

The Georgia Tech Research Institute (GTRI) has installed a large Compact Range for the U.S. Army Electronic Proving Ground at Ft. Huachuca, AZ. The purpose of the range is to test microwave and radar antennas attached to various vehicles. The range consists of a large parabolic reflector, a positioner to hold the target vehicles, a microwave RF path, and a computer system to run the range and collect the data. All of these various sub-systems when combined together comprise the Compact Range. This document is to be used to verify and specify the operation parameters of this system.

1.1 System Specifications

Because of the research nature of this program, specific boundaries for operational parameters could not be defined at the beginning of the program. As a result, the data collected during the acceptance test will establish these operating parameters for the range. However, some items were specified in reference A of subsection 1.2.

1.2 Related Documents

A. Proposal No. ST-MS-1701R1, Compact Range Development. Proposal to U.S. Army Electronic Proving Ground from Georgia Tech Research Institute (GTRI) dated December 1986.

B. GTRI Subcontract No. A-3922-S1 with ESSCO, Concord, Mass. Compact Range Reflector.

C. GTRI Subcontract No. A-3922-550-S2 with Logimetrics, Plainview, NY. Traveling Wave Tube Amplifier.

2 REFLECTOR

The reflector was designed, fabricated, installed, and aligned by ESSCO, Concord, MA. The main criteria for acceptance is the alignment of the surface and the location of the focal point. The GTRI subcontract specified surface tolerances based on different diameter sizes measured on the reflector face. Photogrammetry was the test metnod used to check the alignment of the reflector. GSI Inc. of Melbourne, FL, photographed the reflector and performed the necessary analysis to locate the focal point and to determine the RMS error of the surface. The following results where reported by GSI:

Focal Length	Specified	Reported
	1800.00 in.	1800.189 in.

RMS Error:	Specified	Reported
Central 28 foot radius	0.005 in.	0.00526 in.
Circle 2 (28 - 32 foot radius)	0.025 in.	0.00803 in.
Circle 3 (32 - 37.5 foot radius)	0.050 in.	0.02187 in.

3 POSITIONER

The main structure is a large azimuth-over-elevation positioner capable of moving very heavy loads to produce a hemispherical coverage of the object under test. The structure

has a turntable, a hydraulic motor, a tilt table, two hydraulic cylinders, a manifold block to house the servo valves, and associated cables and hydraulic tubing.

The main tests of the positioner are the functioning of the azimuth and elevation axis.

3.1 Limit Switches

Each axis has a set of limit switches to halt motion. The elevation limits are set at 0 and 90 degrees. The azimuth limits are set at TBD and TBD degrees. The azimuth limits can be over-ridden to permit continuous 360 degree rotation. The elevation limits can be over-ridden to permit motion of the cylinders into the mechanical cushions at the end of the travel.

3.1.1 Azimuth Axis Limits

The proper operation of the Azimuth Axis Limits was verified and the actual limit values recorded.

	Specified	Actual
Limit Switch Actuation Verified		mn
Clockwise limit	TBD deg.	+170 ~~(+190)~~ (-190) (+193) mn STM
Counter-clockwise limit	TBD deg.	-167

3.1.2 Elevation Axis Limits

The proper operation of the Elevation Axis Limits was verified and the actual limit values recorded.

	Specified	Actual	
Limit Switch Actuation Verified		YES	
Up limit	90 deg.	90.49	90.63
Down limit	0 deg.	-0.18	-1.40
		ELECTRICAL LIMITS	MECHANICAL LIMITS

MW STM

3.2 Hydraulic System

The hydraulic system consists of the main and auxiliary pumps, a pair of hydraulic cylinders for elevation motion, a hydraulic motor for azimuth motion, and servo valves to control each axis. All items must be functional for the entire system to perform correctly. The servo valves cannot be individually checked. However, if both the azimuth and elevation axis move smoothly, then the servo valves are functioning correctly.

3.2.1 Pump

The prime mover for the positioner is a large hydraulic pump located in the underground enclosure. Associated with this unit is also an auxiliary pump that circulates the fluid through a cooling loop to a heat exchanger. The pump unit incorporates low fluid level and over temperature sensors to shut the unit down.

The main test of this unit is that both pumps operate normally when turned on. Both the operation of the low fluid level and over temperature sensors will be demonstrated. The low fluid level will be tested with a long wire to depress the float in the hydraulic

fluid tank. The high temperature will be tested by turning off the cooling fan and operation the azimuth axis until the high temperature switch closes.

	Verified
Pump operation	mw JMH
Low fluid sensor	mw JMH
Over temperature sensor (SHUT-DOWN @ 115°F) RE-ADJSTED TO 150°F AFTER TEST	mw JMH

3.2.2 Hydraulic Cylinders (Elevation Axis)

The hydraulic cylinders move the elevation axis and lift an assembly known as the "tilt table". The main test is that the cylinders extend and retract smoothly under various speeds and minimum and maximum loads. There may be some slight jerks as the cylinder moves. However, movement should be smooth enough so as not to preclude accurate data collection over the applicable range of speeds. The full extension and retraction of the cylinders will be demonstrated using the mechanical cushions to end the travel. The limit switches will have to be by-passed during this operation.

	Specified	Actual	UNDER FULL LOAD
Speed			
Up			
Minimum	≤ 0.14 deg/sec	≤0.10	≤0.10
Maximum	none	0.755	0.65
Down			
Minimum	≤ 0.14 deg/sec	≤0.10	≤0.10
Maximum	none	0.792	0.72

mw SJM

mw SJM

3.2.3 Hydraulic Motor (Azimuth Axis)

The hydraulic motor moves the 'turntable' located on the azimuth axis. The main test of the motor is that it move the 'turntable' smoothly under various speeds and minimum and maximum loads. There may be some slight jerks as the axis moves. However,

movement should be smooth enough so as not to preclude accurate data collection over the applicable range of speeds.

	Specified	Actual	UNDER FULL
Speed			
Clockwise			
Minimum	≤ 1 deg/sec	≤1	0.2
Maximum	none	14.05	14.28
Counter-clockwise			
Minimum	≤ 1 deg/sec	≤1	0.8
Maximum	none	15.79	13.70

mA SIM

mA STM

3.2.4 Hydraulic System Electronics

The following items are to be tested to establish proper hydraulic system operation with results recorded in Section 3.2.4.7.

3.2.4.1 Neutral Interlock. The neutral interlock feature prevents the startup of the auxiliary and main hydraulic pumps if an axis is selected. The pumps can only start if the system is in neutral (i.e. STANDBY MODE).

3.2.4.2 Hydraulic Shutdown. The hydraulic shutdown switch located on the Annunciator Panel disconnects power to the hydraulic pumps once they have been started. Restarting the pumps has to be done in the hydraulic pump room.

3.2.4.3 Compensator Override. The compensator override switch located on the Annunciator Panel actuates a vent for the compensator valve located in the hydraulic pump room. This switch will bring up the compensator. This will be tested by reading the Hydraulic Power Unit supply pressure.

3.2.4.4 Emergency Stop. Emergency stop switches halt the current axis in motion. The axis will remain stopped as long as the switch is latched. Motion will resume when the switch is unlatched. Switches are located in the control room, at the top of the positioner and at the bottom of the positioner.

3.2.4.5 Emergency Power. Emergency power provides for continued axis control in the event of a power failure in the control room. The emergency power switch is located on the Hydraulic Interface Unit (HIU) located in the underground electronic equipment side.

An emergency generator (GFE) should be available to check the capability to park a maximum turntable load from 90 to 0 degrees elevation. The azimuth movement will be demonstrated under maximum turntable load for elevation angles of 0 and 90 degrees. If a maximum load is not available and as long as the emergency generator is able to power the auxiliary pump to full pressure, the above requirement should be met.

3.2.4.6 Local Control Unit. The local control unit provides the operator with manual control of the positioner. The unit can be located at either the positioner top or bottom by attaching the unit to the emergency switch box connector provided. The unit will be demonstrated under normal and emergency power conditions.

3.2.4.7 Recorded Data. The performance of the above features are to be recorded below:

Feature	Pass	Fail	Comment
Neutral Interlock	✓		MW JMH
Hydraulic Shutdown	✓		MW JMH
Compensator Override	✓		MW JMH
Emergency Stops:			
Control Room	✓		MW STM
Top of Positioner	✓		MW JER
Bottom of Positioner	✓		MW JER
Emergency Power ① ②	✓		MW JER
Local Control Unit	✓		MW JER

4 RF PATH and INSTRUMENTATION

4.1 Receiver Linearity and Dynamic Range

Linearity and dynamic range of the receiver with respect to the incoming RF signal will be checked by directly connecting the RF output of the appropriate instrument (depending on frequency) to the RF input of the AUT mixer. With a variable attenuator in the RF signal line and a constant output at the source, line attenuation will be increased in a stepwise fashion and the signal level at the source will be recorded. Tests will be done at low, mid, and high frequencies of the following bands:

	SIGN OFF
a. 6 - 8 GHz	MW LP
b. 8 - 12.4 GHz	MW LP
c. 12.4 - 18 GHz	MW LP
d. 18 - 26.5 GHz	MW LP
e. 26.5 - 40 GHz	MW LP

① Aux pump operation @ full pressure (2800 psi) from 30 KVA generator 3/9/90. Operation of az & el axes from aux pump (line power) demonstrated 3/13/90. [illegible]

② 30 KVA GENERATOR 4/19/90 (FULL LOAD).
ELEVATION AXIS UP/DOWN CONFIRMED.
AZIMUTH CCW ROTATION CONFIRMED.
AZIMUTH CW ROTATION – WILL NOT ROTATE CW DUE TO LOW PUMP VOLUME (NORMAL CONDITION AS AZIMUTH MOTOR IS NOT CAPABLE OF LOW VOLUME MOVEMENT IN THIS DIRECTION – POSSIBLY DUE TO NORMAL INTERNAL LEAKAGE) MW

8

Frequency [illegible] GHz

8340 → 8335 [illegible]

Attenuation (dB)	Signal Level at Receiver (dBm)
8	0.1
18	-9.7
22	-14.6
28	-19.7
33	-24.4
38	-29.5
43	-34.6
48	-39.7
53	-44.6
63	-55.4*

ATTEN	SIGNAL
73	-63* NOISY

Frequency [illegible] GHz

Attenuation (dB)	Signal Level at Receiver (dBm)
0	0.1
10	-9.75
20	-19.8
30	-29.6
40	-39.8
50	-49.6
60	-60.2*

Frequency [illegible] GHz

Attenuation (dB)	Signal Level at Receiver (dBm)
0	-0.8
10	-10.8
20	-20.8
30	-30.9
40	-40.9
50	-50.6
60	-61*
70	-70*

* MEANS NOISY SIGNAL

Frequency 3 GHz

Attenuation (dB)	Signal Level at Receiver (dBm)
0	+0.3
10	-9.5
20	-19.3
30	-29.4
40	-39.6
50	-49.6
60	-60*
70	-70*

Frequency 12.4 GHz

Attenuation (dB)	Signal Level at Receiver (dBm)
0	+0.3
10	-9.7
20	-19.4
30	-29.6
40	-40.0
50	-50.2
60	-60.3*
70	-70*

12.4 - 18 GHz BAND

Frequency 15 GHz

Attenuation (dB)	Signal Level at Receiver (dBm)	
0	0	0
10	-10.0	-10.1
20	-20.4	-19.9
30	-30.1	-29.7
40	-40.0	-42.5
50	-45.4	-45.4
60	-48.9	-45.4
70	-49.0	

LO = 11dBm (source 2)

diff. ATTENUATOR

Frequency 12.4 GHz

Attenuation (dB)	Signal Level at Receiver (dBm)	
0	0	0
10	-9.9	-9.9
20	-20.1	-20.1
30	-29.8	-29.9
40	-39.7	-42.7
50	-46.1	-48.1
60	-50.1	
70	-50.3	

LO = 11dBm (source 2)

diff. ATTEN.

* MEANS NOISY SIGNAL

Frequency 2 GHz

LO -5 dBm (SOURCE 2)

Attenuation (dB)	Signal Level at Receiver (dBm)		
0	0	0	0
10	-10.1	-9.8	-9.9
20	-19.7		-19.3
30	-29.7	-27.4	-26
40	-37.7	-43.0	-34.8
50	-45.0	-44.1	-38.0
60	-46.0		-40.0
70	-47.1		

diff. ATTENUATOR

Frequency 12 GHz

FEED → TWT 18-26.5 GHz BAND

Attenuation (dB)	Signal Level at Receiver (dBm)
0	0
10	-10.1
20	-20.3
30	-30.2
40	-40.0
50	-48 *
60	-55 *

Frequency 22 GHz

Attenuation (dB)	Signal Level at Receiver (dBm)
0	0
10	-10.2
20	-20.0
30	-30.2
40	-40.1
50	-50.0
60	-60.0 *

*MEANS NOISY SIGNAL

Frequency 26.5 GHz

Attenuation (dB)	Signal Level at Receiver (dBm)
0	0
10	-10.2
20	-20.3
30	-30.1
40	-39.8
50	-49.0
60	-57.0*

Frequency 26.5 GHz 8540 → 8537 AMP → DOUBLER → TWTA

26.5-40 GHz BAND

Attenuation (dB)	Signal Level at Receiver (dBm)
0	0
10	-9.8
20	-19.9
30	-29.9
40	-39.7
50	-50*

Frequency 35 GHz

Attenuation (dB)	Signal Level at Receiver (dBm)
0	11.03
10	0.93
20	-9.13
30	-19.20
40	-29.30
50	-40.5*

* MEANS NOISY SIGNAL

Frequency 4.5 GHz

Attenuation (dB)	Signal Level at Receiver (dBm)
0	0
10	-9.8
20	-19.9
30	-30.0
40	-40.3
50	-50.5*

Frequency _____ GHz

Attenuation (dB)	Signal Level at Receiver (dBm)

Frequency _____ GHz

Attenuation (dB)	Signal Level at Receiver (dBm)

13

*MEANS NOISY SIGNAL

SIGN-OFF

4.2 RF Signal Sources mw CP

RF power levels present at the input to the RF feeds with respect to the power output of the RF source will be measured at the low, mid, and high frequencies of the five bands (6-8, 8-12.4, 12.4-18, 18-26.5, and 26.5-40 GHz) in order to characterize each of the three RF paths as a whole. Loss and gain of the individual components in each RF path are determined elsewhere when deemed necessary.

Frequency	P(out) at Source	P(out) at RF input to feeds
C	19.11	14.28

Frequency	P(out) at Source	P(out) at RF input to feeds
B	19.57	15.16

Frequency	P(out) at Source	P(out) at RF input to feeds
A	19.65	14.82

Frequency	P(out) at Source	P(out) at RF input to feeds
D	19.41	14.21

Frequency	P(out) at Source	P(out) at RF input to feeds
[illegible]	19.42	13.71

Frequency	P(out) at Source	P(out) at RF input to feeds
E	19.26	12.77

Frequency	P(out) at Source	P(out) at RF input to feeds
[illegible]	19.61	12.29

Frequency	*P(out) at Source	P(out) at RF input to feeds
[illegible]5	40.8	29.2

Frequency	*P(out) at Source	P(out) at RF input to feeds
22	38.8	33.4

Frequency	*P(out) at Source	P(out) at RF input to feeds
[illegible]	41.6	35.5

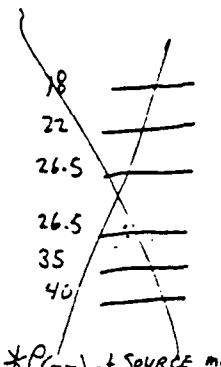
Frequency	*P(out) at Source	P(out) at RF input to feeds
[illegible]	40.9	32.5

Frequency	*P(out) at Source	P(out) at RF input to feeds
[illegible]	38.1	29.3

Frequency	*P(out) at Source	P(out) at RF input to feeds
[illegible]	41.2	29.0

Frequency	P(out) at Source	P(out) at RF input to feeds

Frequency	P(out) at Source	P(out) at RF input to feeds



*P(OUT) at SOURCE measured at TWT Sample port & connected with Sample port coupling values as measured in para. 4.3.

4.3 Traveling Wave Tube Amplifier (TWTA)

SIGN OFF mw SP

The gain and the level at the RF sample port will be checked on the TWTA at least every 2 GHz from 18-40 GHz.

Frequency	'RELATIVE' P(out) at Source	'RELATIVE' P(out) at Sample Port	SAMPLE PORT COUPLING (dB)
18	20.0	~~-5.6~~ -19.8	39.8
20	21.0	~~-2.7~~ -17.9	38.9
22	24.3	~~-5.2~~ -18.9	43.2
24	25.8	~~+0.5~~ -14.7	40.5
Lo-BAND 26.5	25.4	~~-4.4~~ -15.2	40.6
28	27.0	~~-7.0~~ -12.0	39.0
30	28.0	-10.8	38.8
32	25.9	~~-6.2~~ -12.5	38.4
34	31.0	-6.1	37.1
36	24.9	-13.1	38.0
38	22.6	-17.2	39.8
40	21.2	~~-7.0~~ -18.6	39.8
HI-BAND 26.5 (double)	27.3	~~-9.0~~ -12.4	39.7

4.4 Field Probe Data

GTRI is planning to measure the RF field generated by the parabolic reflector with a moving probe. These measurements will be used to show how well the system has been focused as well as the amplitude and phase distribution within the 50 foot diameter "quiet zone". The probe that will be used has been modified for use on this range and will have to be moved twice to cover the entire 50 foot diameter. Initially, only the middle 13 feet will be measured. Depending of the type of data obtained, further measurements beyond the central area may not be made. The measured data will be included as a part of this document.

The field probe data will use the same (or as close to the same) frequencies that were used for paragraphs 4.1 and 4.2.

SIGN OFF

	6-8 GHz	mw STM
	8-12.4	mw STM
	12.4-18	mw/STM
	18-26.5	mw STM
16	26.5-40	mw STM

SIGN OFF

6-8 GHz MW LP
8-12.4 MW LP
12.4-18 MW LP
18-26.5 MW LP
26.5-40.0 MW LP

4.5 Antenna Measurement Confirmation

An antenna measurement confirmation test will be performed in each frequency band using standard gain horns along with the minimum and maximum loads. As a minimum, these tests will be performed for one elevation and one azimuth cut at the peak gain of the test antenna in each frequency band.

4.6 Use of Test Item as Source

SIGN OFF
MW SM

Demonstration of the use of the test item as the signal source will be performed at each frequency band.

5 COMPUTER SYSTEM

The entire range will be operated from a remotely located computer in the control room. This system will perform the actual data collection, moving the positioner, setting up the instrumentation, and analyzing the data. Testing an item involves:

SIGN OFF

MW 1. Creating a test definition.
MW 2. Loading and executing the test definition on the range. This involves automated control of all the instrumentation.
MW 3. Unloading the test. Insuring the database is properly updated.
MW 4. Being able to perform post processing operations on the data such as printing, analysis, etc.

The following items will be checked to determine if the software is functioning properly:

5.1 **Frequency Bands:** (Check harmonic and source 1 multiplier. Frequency list and single point modes.)

	Sign Off
6 - 8 GHz	MW STM
8 - 12.4 GHz	MW STM
12.4 -18 GHz	MW STM
18 - 26.5 GHz	MW STM
26.5 - 40 GHz (frequency doubling)	MW STM

5.2 **Azimuth Increments:**

		Sign Off
0.01 deg.	MW STM	0.03 ACTUAL (NO LOAD CONDITIONS: WITH A COUPLE OF OVERSPEEDS, DID 0.04 WITH NO OVERSPEEDS)
0.05 deg.		✓
0.1 deg.		✓
0.2 deg.		✓

MINIMUM INCREMENT W/MAX LOAD: 0.01 MW STM

5.3 **Elevation Increments:**

	Sign Off
0.01 deg.	MW STM (NO LOAD CONDITIONS)
0.05 deg.	MW STM
0.1 deg.	MW STM
0.2 deg.	MW STM

MINIMUM INCREMENT W/MAX LOAD: 0.01 MW STM

5.4 **Az Limits: (multiple cut test)**

	Sign Off
Detect and recover out of Forward limit.	MW STM
Detect and recover out of Reverse limit.	MW STM

5.5 **El Limits: (multiple cut test)**

	Sign Off
Detect and recover out of Forward limit.	MW STM
Detect and recover out of Reverse limit.	MW STM

5.6 **Continuous 360 Degree Test With/Without Limits Present:**

	Sign Off
	MW STM

5.7 **Wraparound Test With/Without Limits:**

	Sign Off
+180 to -180 deg.	MW STM
+90 to +89.5 deg.	MW STM
+170 to -170 deg. (both points outside limits)	MW STM
+170 to -145 deg. (one point outside limits)	MW STM

5.8 **GPIO Functions:**

	Sign Off
Filter 1 (power unit)	MW STM
Filter 2 (Valve assembly)	MW STM
Panic Switch 1 (trailer)	MW STM
Panic Switch 2 (positioner ground)	MW STM
Panic Switch 3 (positioner top)	MW STM
Path Select Relay	MW STM
Power Supply Relay	MW STM
Az limit override (sets limits present logical)	MW STM
Radiation strobe on/off	MW STM
Lamp test	MW STM

5.9 **Positioner Driver Programs:**

	Sign Off
PLOTX	MW STM
Characterize Az axis speed	MW STM
Characterize El axis speed	MW STM

5.10 **Fast CW Mode**

	Sign Off
	MW STM

5.11 Gains:

	Sign Off
Manual	
Automated	

5.12 Calibration:

	Sign Off
Manual	
Automated	

5.13 Manual Menu:

	Sign Off
Check instruments	
Remote 8510	
Turn TWTA RF on/off	
Power levels	

APPENDIX F. GATED RCS MEASUREMENTS USING THE HP8510 NETWORK ANALYZER

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WHITE PAPER ST-MS-2811

GATED RCS MEASUREMENTS USING THE HP8510 NETWORK ANALYZER

February 1988

Prepared for
USAEPG
FT. HUACHUCA, ARIZONA
ATTN: GRADY BANNISTER

Prepared By
GEORGIA TECH RESEARCH INSTITUTE
GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

UNDER CONTRACT DAEA18-84-C-0050

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Georgia Tech Research Institute is currently under contract to design, develop and install an automated compact range for antenna measurements under contract #DAEA18-84-C-0050 . This range has some unique features which were dictated by the contract requirements especially in handling physically large and heavy vehicles while measuring antenna radiation patterns from 6 GHz to 40 GHz and possibly higher frequencies in the future. This range will provide a plane wave aperture (quiet zone) of approximately fifty feet with an estimated amplitude ripple across the aperture not to exceed 1 dB. To achieve this quiet zone requires careful design of structures to minimize stray reflections from secondary sources such as the ground, reflector supports and the positioner. Techniques utilized are similar to those used to reduce the radar cross section (RCS) of items such as low observable vehicles.

While performing the system design in conjunction with the range design, state of the art range equipment has been chosen based on performance and reliability standards. The receiver chosen for this range is a Hewlett Packard model 8510B Network Analyzer. This receiver provides the desired dynamic range and sensitivity to make the required measurements. However, the 8510 network analyzer has additional features which are currently not planned to be utilized by this range. One such feature, known as the time domain option, can be used to measure returns from many different sources which are interspersed in distance such as primary and secondary reflections. This time domain capability has been used successfully by Flam and Russell, and Harris Corporation to measure the radar cross section of targets with multiple scattering. Recently, similar installations have been planned by Scientific Atlanta.

This white paper is an introduction to additional capabilities of this range which are possible, but to be realized expeditiously, they need to be addressed before the completion of this contract. GTRI, therefore presents this white paper on adding the capability of making Radar Cross Section measurements utilizing the USAEPG compact range.

The proposed instrumentation configuration shown in figure 1 shows the major pieces of equipment required to implement RCS measurement capability. Signal sources which are currently being planned for use in antenna measurements on the compact range will be used for RCS measurements also. The HP 8510 will function as the measurement receiver in both configurations. Two feeds identical to the ones designed for antenna measurements will be mounted on the feed support structure coincident to the reflector focal point. One feed will transmit gated RF energy via the reflector to the target on the positioner while the other feed will receive that energy back from the target. The target's return will then be calibrated by normalization to the return from a calibration target (sphere) and the true radar return will be displayed.

Figure 2 shows more detail of the equipment installation required to perform gated RCS measurements. The requirement for gating is dictated by the possibly large signals due to transmit-to-receive feed coupling, the return from the vertex of the reflector, and possibly large returns from positioner structures. Large returns can saturate the receiver, thus limiting the amount of energy that can be transmitted. The strengths of these returns will be reduced as much as possible through careful range design, but the requirement to measure low RCS targets necessitates improving the system's measurement dynamic range as much as possible. This will be accomplished through the use of transmit and receive gating. This will allow a burst of RF energy to be transmitted to the target which, in time/distance, will be long enough to illuminate the entire target but keep the receive gate closed to the effects listed above. Effectively, the measurement system will become a calibrated radar. The capability to place a precisely controlled illumination window virtually anywhere in the quiet zone will be resident in the measurement software. This is possible by the utilization of an IEEE buss-controllable, dual-channel pulse generator which will in-turn control the transmit and receive gates.

Additional equipment required for RCS measurement is listed in table 1. As can be seen in figure 2, the majority of the expensive required equipment is already planned for use on the antenna measurement system. In addition, there should be no requirement to spend great amounts of time and effort in changing over from antenna measurements to RCS measurements, and vice-versa. The major addition

COMPACT RANGE
RCS MEASUREMENTS WITH HP8510B
6-18 GHz

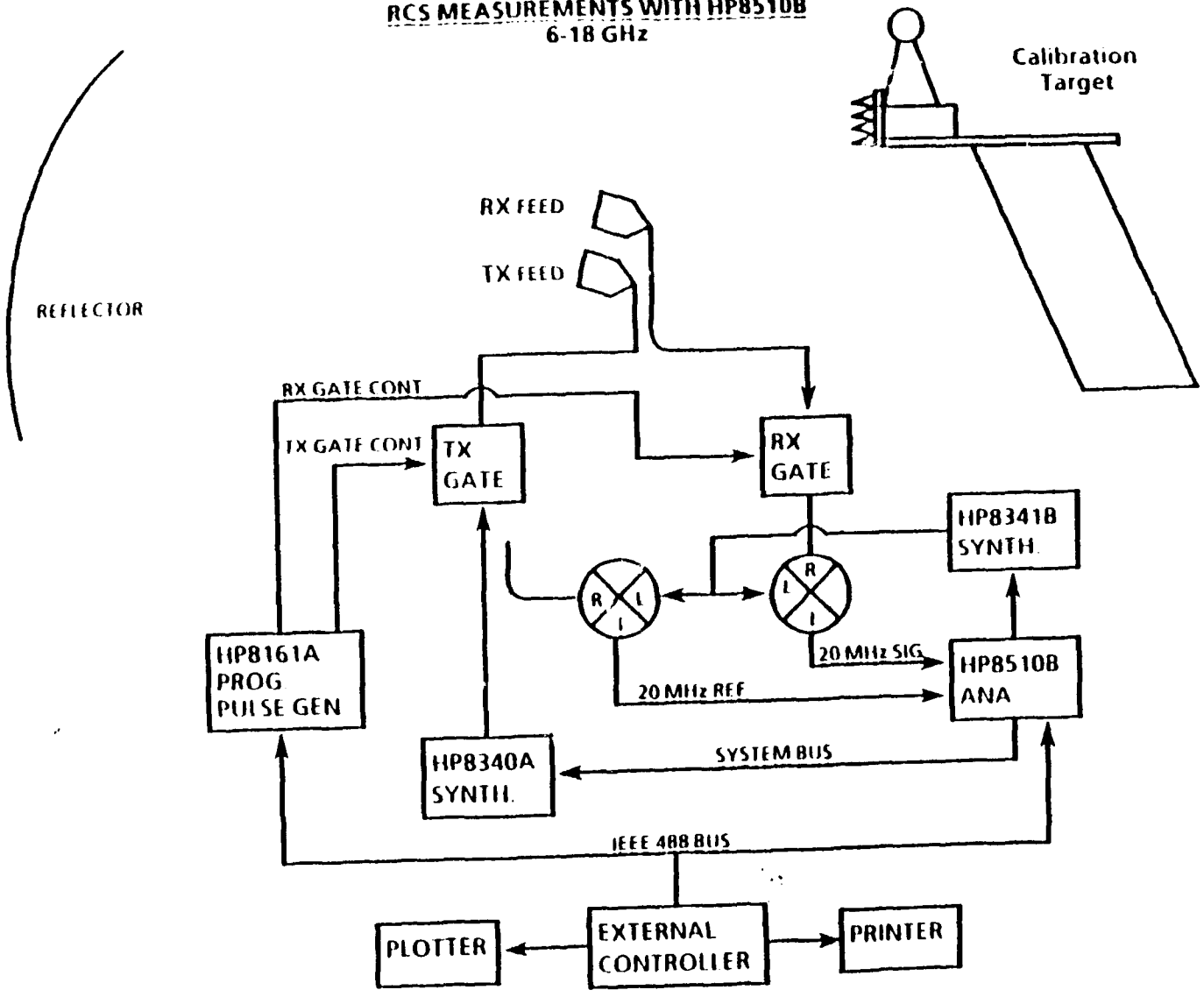
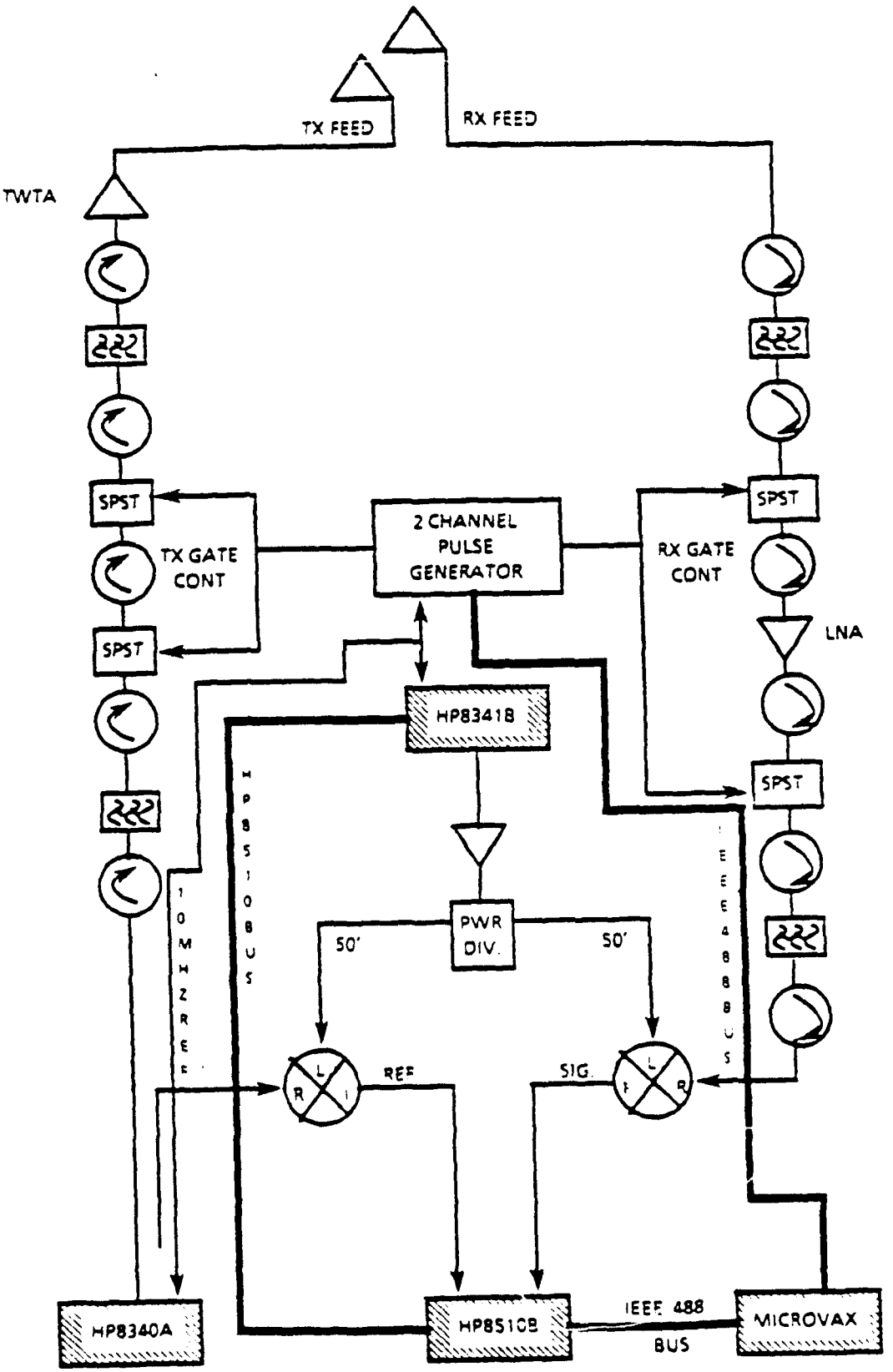


FIGURE 1

RCS MEASUREMENT CONFIGURATION



to the feed support structure equipment enclosure will be the dual-channel pulse generator and the chassis which contains the transmit/receive gating components. The possibility of implementing RCS measurements is being planned for in the design of the current feed equipment enclosure.

TABLE 1. RCS Instrumentation

QUANTITY	ITEM/DESCRIPTION	UNIT PRICE	TOTAL PRICE
4	Amer/Mw SW2184-1	$550	$2,200
11	West/Mw PMI-6018	453	4,983
1	Narda 3292-2	1,370	1,370
1	HP 8161A opt 002	23,500	23,500
1	Avantek LNA	4,000	4,000
4	K&L Mw 20 MHz Fltr	495	1,980
50 ft.	Low Loss Cable	40	2,000
1	RF Encl. Isolated	1,000	1,000
1	Feed Holder Assy.	2,000	2,000
		TOTAL	$43,033

GTRI suggests the use of the 8510B Network Analyzer to make CW or stepped CW Radar Cross Section measurements from 6 to 18 GHz. This would require:

1) Further considerations while currently designing the feed enclosure and mounting hardware to allow two feeds to be mounted adjacent to one another at the reflector focal point.

2) Construction of additional feed mounts for C,X,and Ku band feeds.

3) Additional purchase/manufacture of hardware including hardware gating to prevent receiver saturation if large extraneous returns are present.

4) Personnel time to modify the software for data collection and display.

5) Personnel time to perform tests to validate RCS measurements.

ST-MS-2811

6) Purchase of some RCS measurement standards such as spheres.

The range would be currently designed to accept these modifications. Testing for RCS measurements would occur only after initial range installation and acceptance by USAEPG.

Total Estimated Cost **$198,126**

This white paper describes a low cost upgrade to validate the concept of making RCS measurements on the USAEPG compact range. The suggested program will require the purchase of additional equipment and performing tests to determine the quality of measurements which can be made. A major concern is the large radar cross section presented by the positioner and whether the return due to it could be removed utilizing the time gating features of the HP 85108 Network Analyzer.

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APPENDIX G. REFERENCES

1. Compact Range Preliminary Design Study, Methodology Investigation, O. D. Asbell and E. B. Joy, Task Report on Contract DAEA18-84-C-0050, P00002, GTRI Project No. A3922, Georgia Tech Research Institute, September 1985.

2. Spectral Evaluation of Reflector Surfaces, E. B. Joy and R. E. Wilson, Task Report on Contract DAEA18-84-C-0050, P00006, GTRI Project No. A3922, Georgia Tech Research Institute, August 1986.

3. Feed Study for USAEPG Compact Range, D. G. Bodnar, Task Report on Contract DAEA18-84-C-0050, P00006, GTRI Project No. A3922, Georgia Tech Research Institute, August 1986.

4. Shaped Edge Serrations for Improved Compact Range Performance, E. B. Joy and R. E. Wilson (Proceedings of the 1987 Antenna Measurement Techniques Association Meeting, Ottawa, Canada, 23 through 25 September 1986).

5. Low Side Lobe Reflectors for Compact Ranges, E. B. Joy and R. E. Wilson (Proceedings of the Eleventh ESTEC Antenna Workshop on Antenna Measurements, Gothenburg, Sweden, 20 through 22 June 1988).

6. A Model for the Quiet Zone Effect of Gaps in Compact Range Reflectors, D. N. Black and E. B. Joy (Proceedings of the 1988 Antenna Measurement Techniques Association Meeting, Atlanta, Georgia, 12 through 16 September 1988).

7. Compact Range Reflector Technical Specification, Contract DAEA18-84-C-0050, GTRI Project No. A3922, Georgia Tech Research Institute, June 1987.

8. The Design and Structural Analysis of a Large Outdoor Compact Range Reflector, Michael J. Brenner, Joseph Antebi, and Donald O. Dusenberry, 27 July 1990.

9. Final Report, Photogrammetric Measurement, ESSCO Compact Range, Fort Huachuca, Arizona, GSI, 11 August 1990.

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APPENDIX H. ABBREVIATIONS

AUT	antenna under test
AZ	azimuth
C band	6 to 8 GHz
CW	continuous wave
dB	decibel(s)
dBi	decibel(s) referenced to isotropic
EL	elevation
EM	electromagnetic
EMC	electromagnetic compatibility
EMI	electromagnetic interference
F	focal length
F&R	Flam and Russell
F/D	ratio of focal length to diameter
FASS	Frequency-Agile Signal Simulator
GHz	gigahertz
GPIO	general-purpose input/output
gpm	gallons per minute
GTRI	Georgia Tech Research Institute
HCU	hydraulic control unit
HIU	hydraulic interface unit
HP	Hewlett Packard
hp	horsepower
HPU	hydraulic power unit
Hz	hertz
IEEE	Institute of Electrical and Electronic Engineers
IF	intermediate frequency
K band	18 to 26.5 GHz
Ka band	26.5 to 40 GHz
kHz	kilohertz
Ku band	12 to 18 GHz
LO	local oscillator
MHz	megahertz
psi	pounds per square inch
QRC	Quick Reaction Corporation
RAM	radar absorbing material
RCS	radar cross section
RF	radio frequency
RMS	root mean square
rpm	revolution(s) per minute
RSS	root sum square

S/N	signal-to-noise ratio
SA	Scientific Atlanta
SCR	silicon-controlled rectifier
SIU	system interface unit
TSU	tach servo unit
TWT	traveling wave tube
TWTA	traveling wave tube amplifier
USAEPG	US Army Electronic Proving Ground
X band	8 to 12 GHz

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